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Metal Progress

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Vol. 44, No. 6

Ernest E. Thum
Editor

Cover is from a pencil sketch, made on the site by Hugh Ferris, and shows a segment of the intake scroll casting being lowered into one of the wheel pits at Grand Coulee dam.

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Non-Ferrous Metals

Post-War Planning for the Common Metals

NOTEWORTHY in more ways than one was the Group Meeting on Post-War Planning in Non-Ferrous Metals, held at the Chicago National Metal Congress in October. It was probably the first meeting at an ⊜ convention addressed by industrial representatives on a purely industrial topic. The very large attendance was proof of its importance — a discussion of nothing less than the continuous operation of a considerable segment of the metallurgical industry.

Two of the speakers, on aluminum and magnesium, desired that their remarks be regarded as off-the-record. It may be said, without violating this stipulation, that the principal problem before these two branches of the metallurgical industry is how to administer the vast productive capacity installed to serve the aircraft program. Some of the high-cost plants will undoubtedly be closed, but since so many of the new ones are owned by the Government, there will undoubtedly be much political pressure to keep them in operation, even at a loss. The existence of a large amount of metal in stock and in process — estimated at from two to ten years' civilian supply — will further complicate the situation, unless an adequate stock-piling program is instituted, something like the one recommended by Mr. Willard (page 1095).

One long-range trend is undoubted: On account of the unlimited amounts of ore widely available, aluminum and magnesium together with iron will form the basis of our mechanical civilization. The other "common" metals are really by comparison "semi-precious". The wider application of both the light metals will come on apace by virtue of their present use in the aircraft industry. Engineers know much more about their properties; fabricators know much more about their handling; the general public is likewise thoroughly conditioned to their acceptance.

Following is a "Critical Point" on magnesium, written by the Editor after several discussions in recent months. Then will come the talks about zinc, on lead, and on stock-piling, as presented at the Group Meeting mentioned at the outset.

Competitive Position of Magnesium

A Critical Point by the Editor

HEARD MUCH about magnesium of recent days, and puzzled by the effort of some enthusiasts to gloss over shortcomings of the alloys in their present embodiment — even to converting them into suppositious advantages, which is nice if you can do it. And so was reminded of an old rumor about Canada Dry; caught in depression with enormous amounts of unsold beverage, the astute sales manager let it be known that ginger ale was far better for being aged in the wood, and so profitably liquidated the overstock! Methinks, however, that metallurgists should stay close to their facts, confident that in the long run magnesium, like all engineering materials, must be used or discarded on what real advantages are inherent or can be built into them by art or science. The omnipresence of the ore, the light weight of magnesium metal, its ready workability, and the favorable strength-weight relationship of the alloys are powerful advantages; naturally there are some countervailing disadvantages such as high coeffi-

cient of expansion and susceptibility to stress corrosion — to say nothing of high cost. While all such may be overcome in considerable measure when this baby in the family of metals gets older, magnesium has a bar sinister (if one may so dub its hexagonal crystalline lattice) and it is hard to see how research and development can change this. JOSEPH HANAWALT, director of Dow's metallurgical department, showed how this atomic architecture is responsible for the "directional" properties of wrought products — that is, lower yield in compression than in tension, which requires designing and forging the part so the principal direction of metal flow is properly oriented for the imposed stress. . . . Learned about a steady increase in the amount of magnesium castings, forgings and sheets in the aircraft engine, structure and auxiliaries; the "all-magnesium" fuselage may eventually emerge. Learned also that a study of two modern German planes showed that our enemies — who have longest acquaintance with magnesium, and who by the necessities of war must be doing their best with it — the Germans, I say, are using magnesium in about the same way and in the same amount that we are. German alloys are not our standards, but they are all known to us and have been studied intently and are no better. We heat treat all our castings; they heat treat only the large ones. They also seem to ignore the corrosion bug-a-boo, relying mostly on paint, and in fact no corrosion damage was found in the magnesium parts of these planes and engines. The only important innovation by the Germans is large streamlined forgings of magnesium alloy for the mounts of in-line engines.

Zinc, Zinc Coatings, and Zinc Alloys

By Ernest V. Gent
Secretary, American Zinc Institute, Inc., New York City

THE RESTRICTIONS imposed by the Censor will delight those in the audience allergic to statistics, but it would be much easier to deal with zinc in the peacetime to come if more figures could be stated. However, we do not need statistics to emphasize the point that there will be more than sufficient smelting capacity for peacetime needs in the United States.

For many years, we have had ample smelting and refining equipment to produce sufficient slab zinc to meet our normal requirements. With the expansion of plant prompted by war demands, this division of the zinc industry will end the war with old plants modernized and with new plants and additions adequate to meet all consumer needs. During the war period, domestic mine production has been supplemented by importation from foreign sources, which, under existing economic and political philosophy, is likely to continue — to some degree at least. In any case, it is reasonable to expect that, unless the war period should extend far, far beyond present estimates, sufficient ore and concentrates will be found to match smelting operations.

One of the most difficult problems likely to be met in the post-war period is the accumulated stocks of strategic minerals and metals in the hands of Government departments and agencies, including the Army and Navy. The Zinc Institute, on behalf of the zinc industry, has endorsed the policy of Government stock-piling and urges that stocks at the end of the war should not be liquidated, but conserved as part of our natural resources against future emergencies. Stock-piling of these excess stocks will not only provide for future defense needs, but also will enable mines, smelters and refineries to continue employment which otherwise might be impossible.

It would be interesting if we could predetermine the price levels likely to be met in the future "normal" market but we are up against too many variable factors for anything but wild guessing, and that would not be particularly useful in this discussion. However, in considering sales and distribution problems, we know from experience that certain fundamentals remain reasonably constant; and on this premise we can size up zinc's position in the future market with some degree of confidence:

Galvanizing has always been the largest outlet for zinc in peacetime. In an average year, from 40 to 50% of all slab zinc is used for coatings. The reason for this is well known. Long ago, the National Bureau of Standards termed zinc "by far the best for general rustproofing". Zinc not only gives mechanical but also electro-

chemical protection. Again quoting the Bureau of Standards, "Zinc, then, has the advantage of being electronegative to iron and so prevents its corrosion, especially on small exposed areas, such as 'pinholes' in the coating, scratches, etc."

The Zinc Institute has always been of the opinion that the opportunities for increasing the outlet for galvanized products are tremendous. In the farm field particularly, we see increasing possibilities in the standardization of farm buildings. Steel on the farm, in the form of buildings pre-fabricated and otherwise, was all set for a great expansion program but was delayed by the outbreak of the war, and in practically all these plans, zinc coatings are a vital part of the new designs.

In recent years a great deal of attention has been given to the improvement of zinc coatings. Design of galvanizing machinery has been revolutionized, and given much finer mechanical and metallurgical control. Patented processes have been developed which have led to new types of zinc coated sheets, strip and wire. Added uses have been developed, and the war has accelerated, rather than curtailed, this trend. The thousands of mechanics who have learned to work with zinc-coated materials in war plants will retain this knowledge and skill, and later apply it to more and more civilian goods.

In 1938, the latest normal year, zinc in brass represented about 25% of the total zinc consumption. Considering the starvation of civilian uses during the war period, and visualizing the reconstruction era certain to follow, it seems reasonable to anticipate at least as large a tonnage from this particular market as in earlier peacetimes. Imagine the possibilities for brass in the new construction and in all the remodeling which is contemplated. Then there is the anticipated demand for such things as radios and refrigerators, which in all post-war studies is rated in very high figures.

Zinc alloy die castings have firmly established themselves in a little more than ten years, coming from a very minor outlet to a market for 125,000 tons or more of special high grade zinc every year. The process of die casting is a modern high speed production method, and the zinc alloys offer interesting characteristics in the product with economy in its manufacture. The main applications of die castings in the pre-war period were in automobiles, followed by household appliances such as washing machines, refrigerators and kitchen appliances, and in tools and hardware. The use of zinc alloy die castings in the years immediately following the end of the war should bear a very definite relation to this pattern.

It is also reasonable to assume that the post-war position of rolled zinc will be similar to its pre-war position. The larger outlets for rolled zinc, such as dry battery cups, fruit jar caps, lithographer's sheets, photo-engraver's plates, address plates, eyelets, and hull and boiler plates, are based upon certain characteristics of this particular metal, and rolled zinc will undoubtedly long continue to be used for these items in normal tonnages.

Some of the smaller uses which have been converted to substitute materials because of present conditions may be lost, but it is probable that these losses will be offset by the development of new outlets.

The two largest outlets for zinc pigments in the years between World War I to World War II were for paint and rubber. These have continued to be substantial outlets for compounds of the metal since Pearl Harbor, despite the very considerable changes made in paint formulation (because of the shortages of various vehicles) and in rubber compounding (because of the introduction of synthetic rubber).

Today, approximately 75% of the paint which is made is being used for war and allied purposes, while private property is not being maintained to the desired degree. All signs indicate that there will be a big market for paint in the years following the end of hostilities, with zinc pigments in a prominent place. It also seems that the degree to which synthetic rubber might replace crude rubber is a far less important factor than that rubber may be used in many more applications in post-war products than it was in 1940. Such an increased use of rubber should mean an increased use of zinc pigments.

Zinc was one of the first of the metals to land in the spotlight soon after the outbreak of the war in Europe. This early emphasis upon zinc proved to be an advantage rather than otherwise and, in spite of the good-sized job which had to be done, neither military nor essential civilian requirements have suffered because of any shortage. The zinc industry will continue to rate war needs as of first importance and then, with the benefit of its early experience, will hope to wrestle successfully with post-war problems as they appear.

Lead; a Relatively Plentiful Common Metal

By Felix E. Wormser
Secretary-Treasurer, Lead Industries Asso., New York City

A RECENT friendly advertisement of a sister non-ferrous metal, aluminum, was kind enough to state, "In any discussion of materials, lead carries weight!" I hope that this clever comment will be shown to be correct, even though no one can now make, with any clarity, an appraisal of the situation in lead after the war is over. Certain observations, however, seem quite safe at this time:

In the first place, the United States will continue to be the world's principal producer, even though its resources have been tapped in the last 25 to 30 years to such an extent that the reserve position has been deeply impaired. Even old and long continued producers in the mining business have a habit of coming to the end of their life, since mining is a "one-crop" business. For example, this year the great Hecla mine in Idaho, with a famous history as a lead producer, comes to its end. Sad to relate there is no new discovery of which I know to compensate for its loss — in fact, no really significant lead deposits have been discovered in the United States in the last 15 or 20 years.

It is quite possible that production from lead mines in the United States *after* the war will be lower than it was *before* World War II, but a lot will depend on the price of lead which then prevails. In the past, lead production has been greatly influenced by price, and I think that situation will continue to exist. Nevertheless, we may look forward to a comparatively large production of lead in the United States for many years to come, but no one knows the extent of our reserves for the simple reason that it is not customary, and far too costly, to block out the ore completely.

Although the lead economy of the United States is usually self-contained, in the sense that domestic consumption balances domestic supply, it is reasonable to expect that in the post-war era we shall have to draw upon Mexican, Canadian, Peruvian or other foreign sources of metal or ore. We have been fortunate during this war to have these sources readily available to us to help satisfy the current huge wartime demand.

When we turn to the other side of the picture and examine the future outlets for lead, the industry can take great comfort in the widespread utility of the metal. Lead has an amazing diversity of uses — a source of great strength to the industry because, even though some uses may be competitively displaced from time to time, others more than make up for the change. In addition, lead invariably benefits no matter what segment of the domestic economy happens to feel the pulse of good business. Lead will always be found in such a prosperous area, doing some kind of a useful job!

Sometimes I feel that it is fortunate lead does carry weight, and other times regret that weight is a barrier to its wider use, but nature has endowed each element with certain physical properties which cannot be changed and the engineer must select his materials with those characteristics in mind. Numerous uses of lead which depend upon weight readily come to mind. There is, first of all, the current large use of lead in ammunition, essentially because lead gives concentrated weight in small caliber projectiles and therefore highly desirable ballistic properties. Then again, lead is used in naval vessels as ballast. It is used as counterweights in anti-aircraft artillery. Oddly enough, lead is also used for its concentration of weight in one application where the reduction of excess weight is a paramount objective; I refer to the use of lead counterweights in airplane construction to help operate rudders and ailerons.

In fact, the tonnage of lead used purely because of its weight runs into a large figure, more in wartime than in peaceful applications.

There are, to be sure, many other physical qualities of lead that have been seized upon for important applications. For example, its softness and ductility make it easy to extrude lead into pipe or roll it into sheets, or to make foil, or to use as cable sheathing. Cable sheathing is normally our second most important outlet and its future, both in telephone

and power cable, looks particularly attractive as the country grows. Then, the comparatively low melting point of lead has been utilized in alloys with tin for various types of low melting solders and bearing metals and for type metals. Lead's well known resistance to the penetration of X-rays has made it a standard shield where such equipment is used.

All of these uses run into large amounts of metal per year and give lead a variety of application which is equalled or exceeded by few metals. This is a blessing to the miner because he is not dependent on a few ultimate outlets to absorb his product.

I have mentioned so far only uses of lead in metallic form but there is another huge field of uses which, strictly speaking, is not within the purview of the ⊖. I mean the use of lead in the form of chemical compounds rather than in metals. Yet, that field must be included in any picture of what the future of lead may be. Recently I estimated that about 10% of current consumption is primarily utilized because of the weight of lead, 30% because of its softness, malleability and high corrosion resistance, 24% because of its alloying properties, and 33% for its chemical compounds.

There are a great many useful chemical compounds of lead and most of them are well known to you. For example, white lead carbonate and sulphate are in the finest paints. Then there is litharge and red lead, the oxides of lead used by the storage battery industry and by the manufacturers of paint, insecticides, enamelware, and by oil refiners. (Incidentally, the storage battery industry, in war as in peace, remains the principal user of lead.)

Other lead compounds, lesser known perhaps, such as orange mineral and the lead chromates, are important industrial raw materials. Another compound widely publicized and doing a lot in the current war effort to help our air force win its battles is tetraethyl lead. All high octane gasolines contain this interesting chemical; its use has risen in importance to fifth place in lead consumption. A new compound is lead azide, a detonating chemical used in munitions.

The future of lead compounds is especially bright. I look to see other applications made of the compounds known today, or wide usage of others in the laboratory stage or yet to be discovered. Remember that after the last war, ethyl gasoline was just an infant.

During the current emergency lead has been fortunate in being one of the least critical of metals and therefore engineers have turned to it to solve some of their problems of restrictions and priorities. I dare say there has been more experimental work done with lead lately than in years. We are now finding lead used as a protective coating material on iron and steel to the largest extent in history, and I expect this use to survive the war because it has proven cheap and effective. Lead collapsible tubes, high lead solder, high lead babbitts, hardened lead pipe and flashing are but a few additional uses of lead that have served in our war economy to conserve more critical materials.

Stock-Piling of Metals and Minerals

By F. W. Willard
President, Nassau Smelting & Refining Co., New York

TO SPEAK to this title one must resist the temptation to discursive exploitation of one's pet hobbies. Only a few of the most significant facts can be recorded, a few basic principles mentioned, and expedient implementations suggested.

The first fundamental fact to be cited is the known relative abundance of the elements of the earth's hydrosphere and lithosphere, more or less accessible to man. Fourteen elements constitute over 99% of the mass of the earth's shell. They are arranged as follows:

Oxygen	46.46%	Magnesium	2.07%
Silicon	27.61	Titanium	0.62
Aluminum	8.07	Hydrogen	0.14
Iron	5.06	Phosphorus	0.12
Calcium	3.64	Carbon	0.09
Sodium	2.75	Sulphur	0.06
Potassium	2.58	Chlorine	0.05

The remaining 78 elements total a fraction approximately the same as titanium, and of course include those strategically essential metals, copper, lead, zinc, tin, nickel, manganese, chromium, molybdenum, tungsten, antimony, mercury, and vanadium.

So much for relative abundance — but distribution is not uniform and is less well known. Excepting sodium, magnesium and chlorine (which are well distributed in the hydrosphere), and oxygen in the atmosphere, only aluminum, silicon and calcium are rather uniformly abundant in the lithosphere.

Unfortunately, those elements upon which man has largely built his earthly dominion are inequitably distributed. They are iron, carbon, copper, lead, zinc, sulphur, phosphorus, and potassium. This inequity is a major cause of his epidemic wars. So, along with the inequitable distribution of arable land, metals and minerals explicitly or implicitly become foci of international strife, or a potential fabric of international comity.

We of the United States of America have boasted too long and too loud about our abundant material resources. It is to be hoped that the experience of the past three years has brought us to a healthy state of humility. We are exhausting our mineral resources at an appalling rate! Even many informed citizens have not yet awakened to the enormity of it.

Primary consideration of a policy of stock-piling should be based upon *(a)* reasonable stocks of critical, strategic items in the custody of the armed services, *(b)* a national plan of conservation of domestic resources, *(c)* practical international arrangements for accumulation of stores of metals and minerals not economically available from domestic sources, *(d)* research on and development of domestic resources not presently economical.

Implementation of such a policy can be best accomplished by

1. Determining the probable domestic resources known to be economically available under existing technology.

2. Determining the domestic resources known to be not economically available under existing technology.

   2-a. Expert evaluation of the possibilities of successful research on the above group.

   2-b. Definite rejection of research projects on the above items expertly judged to be unpromising.

3. Concentration of international negotiations on Items 2-b first and 2-a second.

4. Early definitive planning on the use of war scrap and surpluses for initial stock-piling.

5. Consideration of the expediency of encouraging private enterprise to take part in stock-piling by granting Federal loans against approved stock-piles as collateral.

6. Establishment of strict standards of availability of stock-piled minerals and metals, to insure that the materials are in proper form and quality, and are properly stored to insure the most immediate availability in the event of an emergency.

Such an undertaking as outlined in the six items above would be inevitably exposed to political manipulation. This of course must be avoided. To this end the establishment of a policy, which is the proper function of the National Legislature, should be made only after non-political expert advice has been obtained by the Congress. Such advice can be had on the various items from the following agencies:

1. Determination of the kinds and quantities needed for reasonable protection in the event of war with another nation or nations: The Army and Navy.

2. Determination of the relative abundance of domestic resources economically available: The Mining and Metallurgical Society of America.

3. Determination of the fundamental economic solutions: The Brookings Institution.

4. Determination of the most promising lines of scientific research and development: The National Academy of Sciences.

5. Necessary exploration for new domestic sources: The United States Geological Survey.

6. Execution of approved research and developments: *(a)* Scientific facilities and personnel of private enterprise and non-profit scientific research institutions under definitive contracts with the Federal Government; *(b)* The National Bureau of Standards and *(c)* The Bureau of Mines.

The suggestions made here are specific to the problem of metal and mineral stock-piling. The underlying principles could well be considered for other commodities, non-metallic.

The preceding suggestions are made after a study of Senate Bill S. 1160, introduced by Senator James G. Scrugham on June 3rd of this year, and a proposed modification of this bill which, so far as I know, has not yet been formally introduced in the Senate. This bill or the proposed substitute falls short of an adequate public policy based upon facts in the possession of competent technologists. The suggestions I have made are intended as a basis of an adequate public policy. Time is not available here to discuss the inadequacy of the proposed legislation. In these days, many questions of public policy are conditioned by the impact of scientific and technologic advances, making correct solutions by expert knowledge possible — whereas heretofore, in the absence of such knowledge, legislators and administrators could only guess and hope.

Short Anneal for Carburized 3312

By C. W. Dietz
Heat Treating Dept., Continental Motors Corp., Detroit

DESPITE wartime shortages in nickel and chromium rather large amounts of the valuable steel known as S.A.E. 3312 are still being used for motor gears and other highly stressed parts of important wartime mechanisms. A glance at the analysis (carbon 0.12%, manganese 0.45%, nickel 3.5% and chromium 1.5%) will show that when properly carburized it should harden very readily. It *does* harden — much too readily for parts that must be machined between carburizing and the final hardening operation! Such machining needs to be done, for example, on piston pins to remove the case from areas where no case is desired, or where protective copper plating is either impractical or inadequate.

Since this steel air hardens, it will usually come from a gas carburizer with a Rockwell hardness of C-50 to 60. Strangely enough, even when parts are pack-carburized and slowly cooled in the container, they are often much too hard for good machining. A traditional slow cool anneal is very likely to make matters worse instead of better. Too often the use of this steel results in a trail of broken tools, scrapped parts, disrupted schedules, and a busy heat treat clogged with re-anneals and badly diffused cases — truly, a bottleneck which cannot be tolerated.

This tough customer, this invention of the devil, can be successfully annealed in from 4 to 8 hr., depending on the type of equipment used. When properly annealed, it can be machined at normal speeds and feeds with ordinary high speed steel tools. If this is news, read on:

A chaotic condition in our plant, inadequately described above, made a change in annealing practice imperative. Up to that time, parts were taken from a gas carburizer, cooled in an insulated cooling chamber, placed in an annealing furnace, heated to 1290° F. and soaked for 2 hr., furnace cooled to 700° F. and cooled in air to room temperature. Time in annealing furnace was 20 hr. Results: Gear teeth with hardness of C-25 to 30, with occasional batches coming out C-30 to 40. Machinability was very poor. Many loads had to be re-annealed — some of them three or four times.

This routine certainly had the essential of conventional annealing practice — that is, *slow* cooling, both in the original cooling after carburizing, and the subsequent cooling in the annealing furnace. Still we needed softer (more machinable) metal, and we had the alternative of slowing down the cooling rate even further, thus tying up our furnaces longer (which, in fact, we had tried without results) or of seeking out one of the so-called "cycle anneals" that were cutting annealing times on other difficultly softened analyses — or so it was rumored. These cycle anneals were based, we understood, on the "S-curves" showing the time for austenite to transform at definite constant temperatures, and the idea is to cool the metal fairly quickly to the temperature where austenite transforms most rapidly into pearlite, and hold the temperature steady long enough for the transformation to complete itself. Unfortunately, we had never seen an S-curve for carburized 3312, so we had to feel our way.

As a first attempt the annealing cycle was changed to a short soak at 1450° F., about 125° above Ac_1, followed by a furnace cool to 1000° F., about 125° below Ar_1. This shortened the annealing time to 16 hr. and seemed to improve machining conditions slightly. It also increased scaling and diffusion of carbon in the case. There were still many tool failures. Some unusually stubborn loads required both types of anneal.

At this point we interviewed several large users of this material. Each was using a different anneal, none of them entirely satisfactory.

It seemed logical that something could be accomplished by transferring hot parts from the

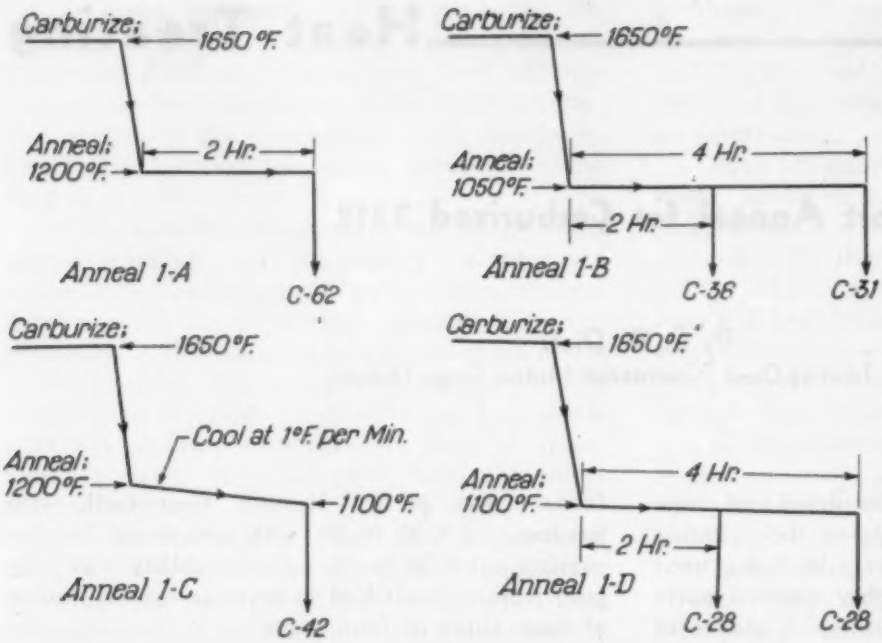


Fig. 1 — Four Unsatisfactory Annealing Cycles for S.A.E. 3312 Wherein the Carburized Parts Were Transferred From the Carburizing Furnace Directly Into an Annealing Furnace and Held at Constant Sub-Critical Temperatures for Times up to 4 Hr.

carburizing furnace direct to the annealing furnace at a lower temperature, and continuing from there. This was tried out on a small scale, typical procedures and results being shown in Fig. 1. It was obvious that the 1200° F. transformation temperature (anneal 1-A) was too high or the time not long enough, for there was enough untransformed austenite remaining in the part to form a lot of hard martensite on the cool from 1200°. The procedure of 1-D seemed promising when tried in a laboratory furnace — possibly 1100° is at or near the temperature where the austenite in this particular alloy transforms most rapidly — but when it was tried on a full production load the results were very disappointing. Some parts were soft, others tested C-45 to 50. The hard pieces, under the microscope, showed a thin layer of retained austenite in the hyper-eutectoid zone. Presumably this austenite transforms spontaneously to martensite under the cold work of hardness testing or of turning, milling or broaching.

In order to verify this finding of a layer of austenite, a standard McQuaid-Ehn test was run on the uncarburized portion of one of the hard pieces. After carburizing at the usual temperature for the correct time, the sample was cooled in the box to room temperature at an average rate of 1.2° per min. Results: C-50 Rockwell hardness, and a coarsely granular layer of austenite, as shown in Fig. 2. This layer disappeared when the piece was heated to hardening temperature and quenched in oil.

At last the villain was unmasked — an austenite which refused to transform with slow cooling but which behaved normally with more rapid cooling. Let it be noted here that this is not necessarily an inherent characteristic of S.A.E. 3312. Many heats of steel from certain mills are entirely free from it, while from other mills it occurs frequently. This should be a useful property if properly investigated and made controllable. However, it certainly complicates the annealing problem.

Fortunately there was at about that time a paper by R. J. Hafsten on annealing S.A.E. 52100 (*Metal Progress*, November 1942) which gave the hint that transformation could be promoted by heating to a temperature which produced austen-

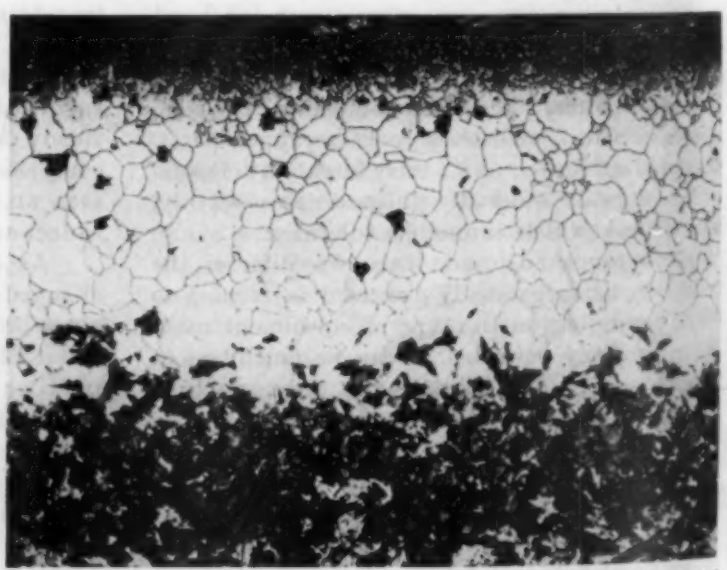


Fig. 2 — Austenite in Hyper-Eutectoid Zone in Slowly Cooled Sample After Carburizing for McQuaid-Ehn Test. Picric acid etch; magnified 100 diameters. In this region the austenite did not begin to transform while cooling from 1700° F. at 1.2° per min.

ite and undissolved carbides. This meant that the austenite formed just prior to cooling should not be entirely homogeneous — that there should be some undissolved particles in the solid solution to nucleate or seed the transformation. Since homogeneous austenite should result from a long time at a temperature considerably above the critical, a non-homogeneous austenite should result from a short anneal at a temperature only a little above Ac_1.

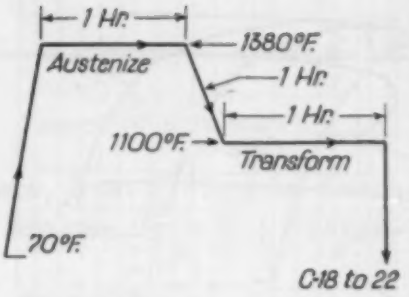


Fig. 3 — Successful Cycle for Carburized 3312, Run in Continuous Furnace After Parts Are Completely Cooled After Carburization

A critical point determination on a completely carburized piece of S.A.E. 3312 showed a transformation on heating at 1330° F., and on slow cooling at 1130° F. With this information a test anneal was run as shown in Fig. 3 with very gratifying results.

This cycle was put into production with suitable adjustments in the time to insure thorough heating of the larger loads, but our troubles were not yet ended; results were very erratic. Some loads could be machined with extreme ease while other loads were absolutely unmachinable even though ordinary hardness tests gave no indication of the fact. An unmachinable piece tested C-25, but when tested on the 15-N Rockwell scale it gave a hardness which would convert to Rockwell C-50. The microscope showed a thin layer of austenite (Fig. 4).

At this time it was noted that if pieces were taken from the carburizing trays while still warm, and reheated for hardening, they had a hardness, after the quench, of C-55 to 57. However, if similar pieces were cooled to 70° F., then reheated and quenched, they tested C-63 to 64. Thinking it was worth trying, the order was given to cool all carburized loads to 70° F. before annealing. Annealing troubles vanished!

The cycle for cold carburized parts, diagrammed in Fig. 3, has been in daily use for nearly a year. There have been a few failures, but each has been traced to failure of human element or equipment. Parts are being machined at 50 to 100 surface ft. per min., with excellent tool life of ordinary high speed steel tools. It has been possible to step up production and at the same time to transfer machine tools and furnace equipment to other jobs where they were badly needed. Over-all costs have been cut considerably. A serious bottleneck has been broken.

In short, to anneal carburized parts of S.A.E. 3312 to an easily machinable condition:

1. Cool completely from carburizing temperature to 70° F. by any convenient means (quench, air cool, fan cool) as long as the cooling is not extremely slow.

2. Heat to 1380° F. Hold long enough to be sure that all parts have reached temperature. A forced convection furnace is ideal.

3. Cool to 1100° F. at any convenient speed. Times varying from 50 min. to 6 hr. have been used with only minor variations in results.

4. Hold at 1100° F. long enough to be sure all parts have reached temperature.

5. Cool to room temperature by any convenient means. Parts have been quenched without bad effects.

The entire cycle need not take more than 8 hr. In a continuous furnace it can be done in 4 hr.

Postscript: After all this work was done a series of very excellent papers on the annealing of steel appeared in *The Iron Age* (five installments starting June 24, 1943), written by Peter Payson, chief research metallurgist of Eastern Research Laboratory, Crucible Steel Co. of America. He establishes seven rules for annealing,

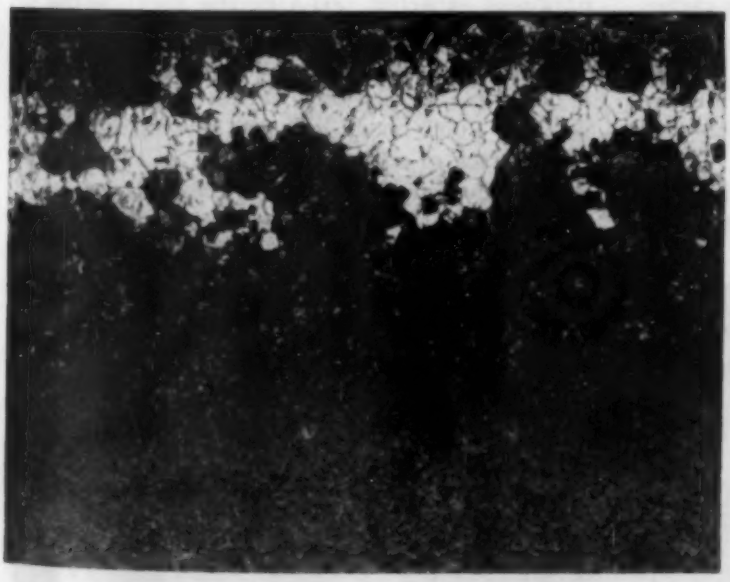


Fig. 4 — Sample Put in Annealing Furnace Before Completely Cooled After Carburizing. Note thin layer of austenite. 100×. (Micros by Thomas Di Gaetano)

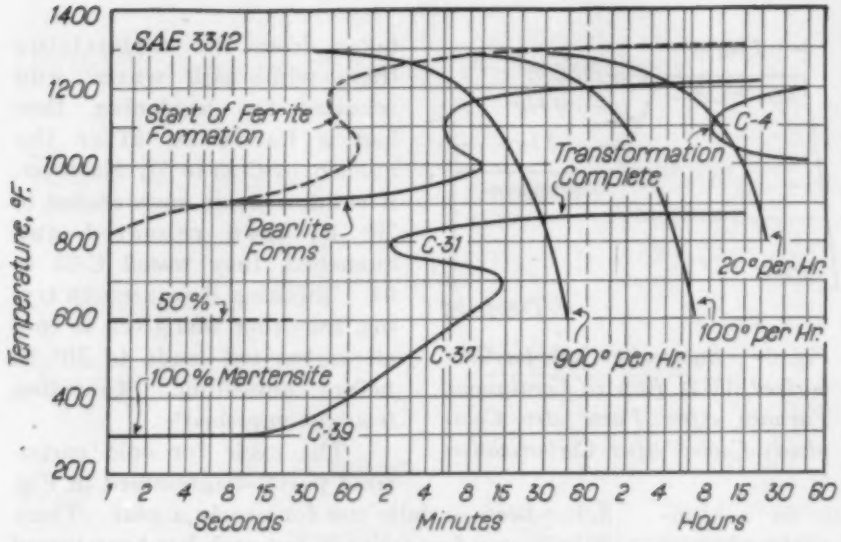
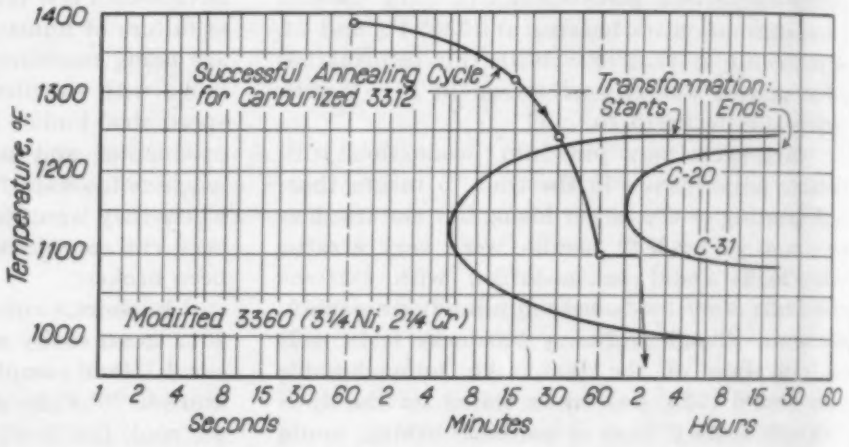


Fig. 5 (Above) — Continuous Cooling Curves Superimposed on Payson's TTT Curve for S.A.E. 3312, Showing That 20° per Hr. From 1300° F. Would Be Required for Complete Softening

Fig. 6 (Below) — Upper Portions of TTT Curves Showing Annealing Conditions for a Modified 3360 Steel. Composition: 0.59% C, 0.34% Mn, 0.26% Si, 3.20% Ni, 2.26% Cr. Austenizing Temperature, 1500°F. Ac_1 1260°F. Prior condition: Tempered 2 hr. at 1150°F. (Courtesy Peter Payson and The Iron Age). Successful annealing time-temperature curve for carburized and cooled 3312 is shown, resulting in easily machinable parts, Rockwell C-20 hard. Curve of end of transformation of the latter must be at left and considerably below the one shown



and among his numerous illustrations will be found S-curves ("TTT" or time-temperature - transformation curves, as he calls them) for 3312 and a modified 3360. These are reproduced as Fig. 5 and 6. The successful cycle shown in Fig. 3 is plotted on Fig. 6, and it will be seen that it would hardly be adequate for the hyper-eutectoid case in our carburized steel containing slightly less chromium (that is, the carburized 3312). The curve representing end of transformation may therefore be located considerably further to the left and displaced further down on the temperature scale — as would indeed be expected from theoretical grounds.

It is also possible that Payson's steels were unusually sluggish. For example, if our successful annealing cycle is also plotted on Fig. 5 it intersects the line "Transformation Complete" somewhere close to the 100° per hr. curve and the hardness expected (even in the core) would be nearly C-30. It would do no good to shoot for the bend in the transformation curve at 1100° F. and 8 hr., for the resulting hardness — C-4 — is too soft for good machining. Whatever the reason for the lack of correlation, it may be said that the cycle shown in Fig. 3 has successfully annealed many heats of steel from several sources.

Tin Plate, Iron Plate and Ferro-Alloys Feature Electrochemical Society Meeting

Reported by Bruce W. Gonser
Battelle Memorial Institute, Columbus, Ohio

THE OCTOBER MEETING of The Electrochemical Society in New York was of unusual interest, not only to electrochemists and electrometallurgists, but to almost anyone in the metal industry. Applications of electroplating to wartime problems were stressed, of course, but there was plenty of other fundamental information presented for peace-time use.

Discussions on electrolytic tin plate undoubtedly attracted the most animated interest — partly because tin plate means tin cans, and tin cans mean food. Dr. B. D. SAKLATWALLA gave a most excellent lecture on ferro-alloy metallurgy. Some new improvements in electrolytic iron plating were presented. Papers on the program included those on the deposition and properties of cobalt-tungsten and nickel-zinc alloys, on corrosion of tin-nickel alloy coatings on steel, on nickel plating of fine steel wire, on electrogalvanizing, on corrosion of silver plated steel, and on corrosion of bearing surfaces of indium diffused into lead. Induction furnaces received attention in one round-table discussion; the relationship between irrigation projects in the Northwest and availability of electric power for electrochemical work in that region was discussed interestingly at one luncheon. Process metallurgy rated a good discussion by COLIN G. FINK and CHUK CHING MA on the recovery of pure tungsten from low grade and complex ores, formerly thought to be of little value. Only the two sessions on electro-organic chemistry were lost, from the metallurgist's viewpoint.

Electrolytic Tin Plate and the Canning Industry

C. E. GLOCK of Crown Cork and Seal Co. described the construction and operation of a commercial plant making electrolytic tin plate in his paper entitled "Electrotinning from Alkaline Stannate Equipment". A construction advantage in using the alkaline electrolyte is that a plain steel tank can be used. Something over 600 ft. of wide steel strip is needed to thread the line, about 475 ft. being exposed to the anodes, by passing up and down in the tank between 48 tin anodes weighing a ton each. It is necessary to keep the temperature high (around 190 to 200° F.) to obtain high efficiency. Speed of operation is relatively low since the current density is kept at about 40 amp. per sq.ft.

By using potassium in place of sodium stannate, as FREDERICK LOHENHEIM pointed out in his paper on "Tin Plating From the Potassium Stannate Bath", cathode current densities from 2 to 6 times as great are obtainable with good efficiency. This is possible because of the greater solubility of the potassium salt and its favorable temperature coefficient of solubility.

Electrotin plating with the acid bath, as E. W. HOPPER of Crucible Steel Co. of America and H. P. MUNGER of Republic Steel Corp. pointed out, is adaptable to large changes in speed of operation; likewise high current densities can be used (as 200 amp. per sq.ft.). This is not only useful when slowing down to weld on a new strip, but tin can be deposited to various thicknesses without major adjustments. At least one line has been designed to operate at 1000 ft. per min., using du Pont's stannous chloride-fluoride bath, with which current densities up to 500 amp. per sq.ft. are claimed. This encouraged COLIN FINK's comment that keeping the electrolyte in the tank was probably a bigger operating problem than the usual one in electroplating, namely, insufficient agitation.

An excellent review of the development of electrolytic tin plate and its application to can manufacture, with observations on many food packs in electrolytic and hot-dipped tin plate cans, was given in KENNETH BRIGHTON's paper on

"Electrolytic Tin Plate from the Can Makers' Point of View". Early troubles in soldering cans made from acid electrotinned plate were balanced by trouble with enamel adherence to alkaline tin plate. A chemical treatment now given the tin plate helps both these manufacturing steps, and also lengthens can life with many food packs. Silver-lead solder is now satisfactorily used to solder either type of tin plate. Melting the electrodeposited tin, as is now commonly done in the line right after electrodeposition, aids solderability, gives better corrosion resistance internally and externally, and aids appearance. Thinly coated electrolytic tin plate (as 0.5 lb. per base box or even less) is expected to find considerable application after the war for miscellaneous products and dry foods. For most processed foods, however, such tin plate must be enameled inside and usually outside. This makes it more expensive than plain hot-dipped tin plate cans. Strategic tin is now being saved by combination cans whose ends are made of enameled electrolytic tin plate, and the bodies of hot-dipped plate (and vice versa), or, for some applications, with enameled untinned ends.

A possible substitute for tin plate in canning was described in "Corrosion of Tin-Nickel Alloy Coatings on Steel in Canned Foodstuffs" by H. R. COPSON and W. A. WESLEY of the International Nickel Co. Tests were made of galvanic couples in several foods, comparing the action of tin on steel with two thicknesses of tin-nickel alloy coatings on steel. This alloy was formed by first electrodepositing nickel, then tin, then diffusing to give a reasonably thick alloy middle zone. The tin content was essential to shift the noble potential of nickel so it could be electroprotective to steel, and because of the excellent effect of tin salts in inhibiting corrosion of steel at pinholes. Results indicated that a 0.00006-in. alloy coating probably would be satisfactory for all foods tested but one, that a 0.00002-in. coating would be satisfactory for a number of foods, and that weight loss by corrosion is less with either than with tin plate.

Improved Iron Plating

An electrolyte and procedure for high tensile, ductile iron for structural purposes was described by W. B. STODDARD, Jr., of the Champion Paper and Fibre Co. The feature of this ferrous chloride bath is the addition of manganese (3 to 5 g./l. of $MnCl_2 \cdot 4H_2O$) to decrease the grain size of the deposited metal, to broaden the range of operating conditions, and to decrease the breaking-in period of the electrolyte. A suitable wetting agent, like "Tergitol 7" or "Gardinol WA", drastically reduced pitting without injuring the ductility of the iron deposit. Many materials were found to embrittle and gas the iron, hence great care had to be used in selecting pure iron anodes and in keeping the solution pure. Tensile strengths as high as 110,000 psi. with an elongation of 10% were reported. The minimum temperature of operation was 160° F., and higher temperatures, as 170 to 206° F., were preferred in order to use cathode densities of around 100 amp. per sq.ft.

The need for iron as a substitute for copper in electrotyping was the basis for an investigation described in a paper on "A Sulphate-Chloride Solution for Iron Electroplating and Electroforming" by R. M. SCHAFFERT and B. W. GONSER of Battelle Memorial Institute. After trying electrolytes covering a wide range of composition, a combination was evolved which is easy to control, is stable, and gives a sufficiently ductile deposit for handling in electrotyping operations. The electrolyte preferably contains about 33 oz. per gal. of ferrous sulphate, 5.6 oz. per gal. of ferrous chloride, and 2.7 oz. per gal. of ammonium chloride. It is used comparatively cold (that is, 70 to 115° F.) and after initial purification by activated carbon and filtration it gives smooth deposits. The electrolyte has been successfully used commercially for over a year in electrotyping and for facing stereotypes to supplant copper and nickel in part or entirely.

Ferro-Alloy Metallurgy

In the Richards Memorial lecture on "Thermal Reactions in Ferro-Alloy Metallurgy, the Basis of Alloy Steel Development", B. D. SAKLATWALLA stated that any technological development which assumes commercial importance generally springs from sound fundamental concepts and research. As a good example, the theoretical principles evolved and researches by Professor RICHARDS served as a guide in developing processes for production of ferro-alloys. Their economical production, in turn, made possible

the present wide commercial use of alloy steels. Some of these high strength, low alloy steels, he believes, may be the answer to the challenge of aluminum as a structural metal.

In his discussion of reduction processes, using aluminum, silicon, or carbon to make ferro-alloys, he emphasized the importance of *rapidity* of chemical action (to keep the heat in place) and of the initiation temperature of the reduction reaction. This has been found to be the temperature at which the oxygen tension of the oxide is 0.21 atmosphere.

Since heats of formation have been found to be a more logical criterion of reducibility than other properties, Dr. SAKLATWALLA plotted the heats of formation against valences, and drew lines to the zero point to give slopes of different angle for each element of interest. Such slopes determined the relative reducibility, and corresponded well with the facts of experience. As many of these metals fall into groups, they may be listed in their order of reducibility — top to bottom in each column:

Comparative Reducing Power of Various Metals

GROUP 1	GROUP 2	GROUP 3	GROUP 4
Ca	Al	Mn	Fe
Mg	Ti	Cr	W
Sr	V	Zr	Ni
Ba	Si	P	Cu
	B	Mo	

Miscellaneous Metals and Alloys

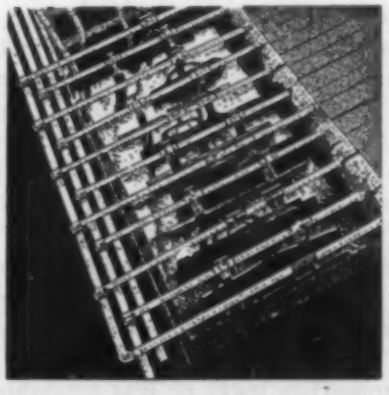
Nickel coating of steel received attention, not only when alloyed with tin for can stock, but with zinc from an electrolyte of mixed chlorides of zinc and nickel (an extension of research on Corronizing by the Standard Steel Spring Co.). In another application of nickel plating, described by J. H. CONOLLY and RICHARD RIMBACH of the Hanover Wire Cloth Co. in their paper on "Continuous Plating of Fine Steel Wire with Nickel", a completely uniform deposit of 0.0002 to 0.0010 in. is made on steel wire for use in supporting tungsten filaments in incandescent lamps and vacuum tubes. The throwing power of the mixed sulphate-chloride-boric acid electrolyte is so good that bars of nickel, forming anodes, are merely tossed onto carbon block contacts at the bottom of the electrolyte. Some 50 wires may be passed through in a group at a speed of 20 to 25 ft. per min. and with a current density up to 1200 amp. per sq.ft. The wire is then annealed in hydrogen and drawn, as from 0.080 to 0.012 in.

Adhesion of electrodeposited silver to steel is markedly improved by first giving the steel a phosphate coating. P. J. LOPRESTI described (in his paper on "Corrosion Resistance of Silver-Plated Steel: Phosphating the Steel Plating") how most of the phosphate coating disappears during the first stages of silver plating, but the steel surface is protected during the moment between wetting the surface and deposition of silver.

Studies by FREUND, LINFORD, and SCHUTZ on "Corrosion of Lead-Indium Diffusion Alloys" verified the chemical corrosion of lead in bearings by lubricating oils. Indium, deposited on the lead and diffused by heating 2 hr. at 155° C., effectively prevented attack by used aircraft engine lubricating oil, provided sufficient indium was present and immersion in the oil was complete. Steel backings plated with lead and then with 0.0001 in. of indium were completely protected under practically all conditions, but a coating of only 0.00001 in. of indium was insufficient in most tests.

The plating of cobalt-tungsten alloys from a cobalt-sulphate-chloride-boric acid electrolyte, to which 1 or 2 g./l. of tungsten was added as sodium tungstate, was described in a paper by M. L. HOLT, R. E. BLACK, and P. F. HOGLUND. Tungsten in the alloy deposit ranged from 1 to 16%; the highest composition resulted from a relatively high tungsten content in the electrolyte, high pH, high temperature, and low current density. Bright, metallic deposits were secured at 70° C.

Electrogalvanizing of steel strip was discussed by E. H. LYONS of the Meaker Co. Although installations are relatively expensive, zinc coatings of any desired weight are readily obtainable and the ductility or formability of the product is far superior to hot galvanized strip. It is possible to make a spangled deposit by using an addition agent, but as the best agent does not last long, its use is impractical.



Alternate and Ideal Steels: Medium Carbon, Heat Treated Steels

By H. B. Knowlton, F. Sailer and E. H. Snyder
Engineering Dept., International Harvester Co.*

SINCE this country entered the war, the metallurgists have been confronted with the problem of selecting alternate steels which will perform as well as the former standard steels, but which will save alloying elements such as nickel, chromium, and molybdenum. So far the effort has been to produce alternate steels which as nearly as possible simulate the old steels in response to heat treatment and in the mechanical properties produced thereby. There has not been time for a critical study of individual parts to determine whether the mechanical properties *specified* are essential.

The National Emergency Steels (NE steels) were devised principally on the basis of duplicating the hardenability of the old S.A.E. or A.I.S.I. standard steels. In the main, these steels have proven to be satisfactory alternates on the basis of service performance as well as laboratory tests. The nickel-chromium-molybdenum steels (NE8600, NE8700 and NE9400 series) have been quite satisfactory for most applications. There have, however, been exceptions where certain of the new steels, particularly the manganese-molybdenum types NE8000 to NE8400, have not been found satisfactory; in spite of the fact that their hardenability was equivalent to that of the old steels, they were sometimes found to be somewhat brittle. These steels have been eliminated from the list of standard National Emergency Steels issued Aug. 15, 1943.

There have been a few places where no satisfactory substitute has been found for the old steels. On the whole, however, it may be said that the big lesson learned in the past two years is that steels with relatively high alloy contents are not necessary for most automotive parts.

The metallurgical problem of the future, possibly even before the end of the war, will be the selection of "ideal" steels for different applications, rather than the selection of alternates whose properties more or less resemble those of the old steels. In a talk before the Chicago Chapter ASM about ten years ago, Dr. Zay Jeffries stated that the ideal steel for any given part was one which was just good enough to give satisfactory performance but not "too good", if the additional quality involved a higher cost. Hence both the present and the future problems involve an attempt to conserve alloying elements. It seems probable, however, that future efforts will be concentrated along the line of a more critical study of individual parts and their service performance, to determine more accurately just what properties are needed, and finally to select the most economical steels possessing the necessary properties. Hardenability will remain one of the important properties to be considered but certainly not the sole basis for selection.

The present article is devoted to the discussion of certain parts, particularly axles and shafts, which are commonly made from medium carbon alloy steels, and will indicate how steels with different properties behave on simulated service tests. It is believed that the data throw some light on the problem of proper selection.

Parts which are commonly made from medium carbon alloy steels may be divided into three general classes:

1. Those which are heat treated for resistance to abrasion or wear.
2. Those which are subjected to more or less uniform tension or compression.
3. Those which are subject to non-uniform stresses, such as produced by bending or torsion.

These three classes will be considered separately in discussing the selection of ideal steels.

Abrasion resistance of medium carbon, heat treated steels is generally proportional to surface hardness, which depends upon the size and shape

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of the piece, the heat treatment, the carbon content, and the hardenability of the steel. Consequently, when surface hardness and resistance to wear are the only requirements, a satisfactory steel may be selected for any given part and heat treatment, on the basis of carbon content and hardenability. Many parts, however, require not only surface hardness but other properties, such as strength and toughness.

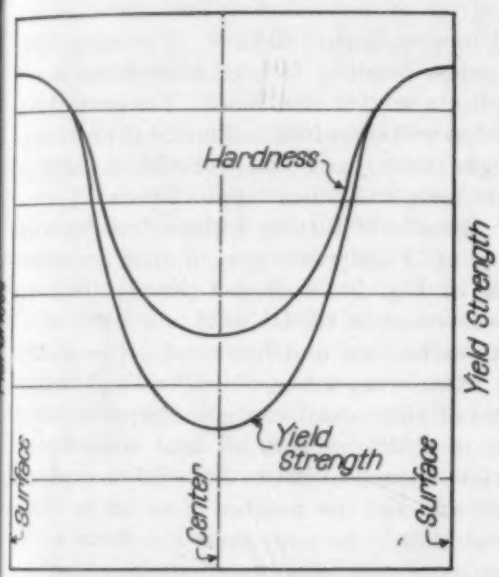


Fig. 1 — Qualitative Relation Between Hardness and Yield Strength at Different Points on a Cross Section That Has Been Hardened Incompletely — That Is, the Completely Martensitic Structure After Quenching and Before Tempering Did Not Extend to the Very Center

Parts Subject to Uniform Tension or Compression — Bolts and studs are usually considered as parts which are subjected to uniform tensile stresses. Actually if only tensile stresses were present and if these stresses were absolutely uniformly distributed over the cross section, the ideal material would be the one having the highest strength and consequently the highest hardness. Glass would be preferable to steel. Experience has shown that some ductility is required in order to equalize the distribution of stress; consequently there is an optimum hardness which should not be exceeded.

Bolts in service may break in bending fatigue, but they require high yield strength and high tensile strength to prevent stretching or breaking in assembly. The tensile strength obtainable with any given *surface* hardness depends upon the penetration of hardness, for the tensile strength at any point on the cross section is proportional to the hardness at that point. Consequently a cross sectional hardness curve becomes a cross sectional strength curve, when the corresponding values of strength are substituted for hardness.

The yield strength of heat treated steels is also proportional to hardness, providing the steel is hardened completely to a martensitic structure before drawing. If the center of a bar falls below a fully martensitic hardness as quenched, the yield strength of that bar will be lower than normally calculated from the hardness. This is illustrated in Fig. 1. Obviously, the highest yield strength and tensile strength in proportion to surface hardness can only be obtained when the hardness is uniform over the entire cross section.

Figure 2 shows the cross sectional hardness curves for different sized bars of 4042 carbon-molybdenum steel after oil quenching and drawing to a surface hardness of about Rockwell C-40. It will be noted that the 1-in. diameter bar hardened through uniformly to the center, but that the 1½-in. bar did not. This means that 4042 steel should be satisfactory for bolts up to 1-in. diameter but would not be entirely satisfactory for 1½-in. bolts. On the other hand, 1-in. bolts made of a variety of steel which would harden through to the center of a 3-in. section would not have any higher tensile strength than bolts made of 4042 steel and heat treated for the same surface hardness. Actually, carbon-molybdenum 4042 steel has been found to be a satisfactory alternate for chromium-molybdenum 4140 so far as small bolts are concerned.

Parts Subject to Bending or Torsion — Examples of parts in this classification are shafts, axles and teeth of full hardening steel gears. In such parts, failures are usually due to bending or torsion fatigue. Failures originate at the surface, usually in the locality of a stress

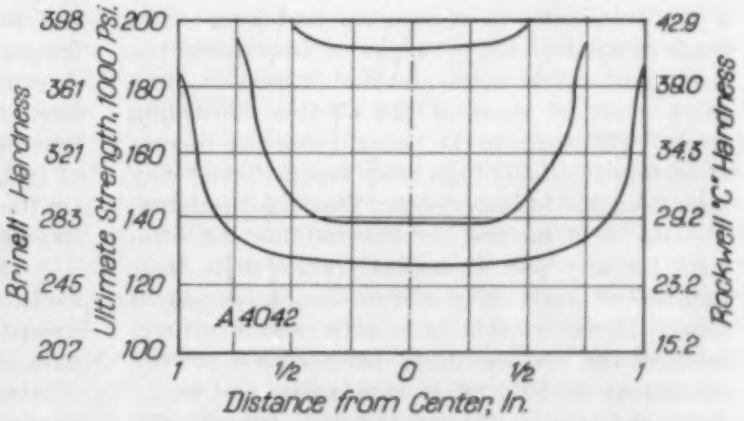


Fig. 2 — Penetration of Hardness in Carbon-Molybdenum A 4042 Steel After Quenching and Tempering to Surface Hardness of C-40. Bars 1 in. diameter harden through; 1½ and 2-in. bars do not. (Chrysler Corp.)

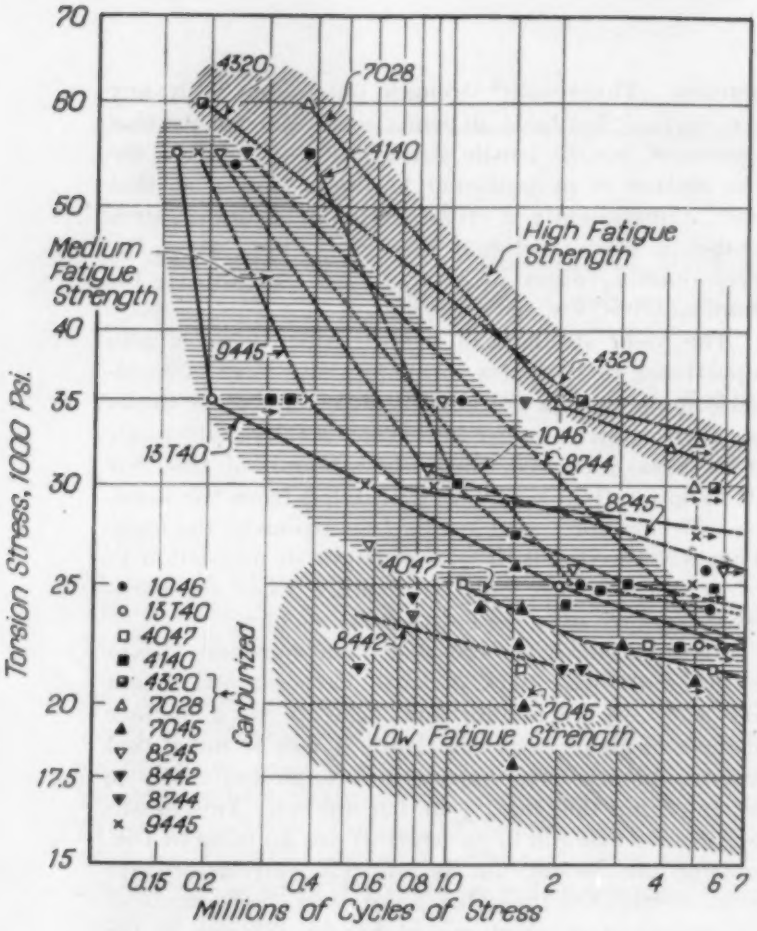


Fig. 3 — Torsion Fatigue Tests on 2¾-In. O.D. Splined Axles, Made of Nine Medium Carbon Steels and Two Carburized Steels. Steels 7028 and 7045 contain 1% manganese and 0.28 and 0.41% molybdenum respectively

raiser such as a fillet at the bottom of a keyway or spline. In bending or torsion, the stress varies from a maximum at the surface to zero at the neutral axis. It seems obvious therefore that deep penetration of hardness and consequent high strength at the neutral axis (the center of round bars) is not at all necessary. On the other hand, it has frequently been reported that large axles made of some of the old types of deep hardening steel gave much better results in service than axles made of some of the shallow hardening steels. This leads to the thought that the success of certain relatively high alloy types of steel may have been due to factors other than hardenability.

The best method for determining the ideal steel for any part is actual service of a large number of parts over a considerable period of time. However, this is a slow and expensive method for testing steel; furthermore, service conditions are difficult to standardize and reproduce, and comparative service tests between different types of steel are frequently far from conclusive. While not disparaging the value of field tests as a final proof, it may be said that the best type of test for determining the relative merits of different steels for service parts is some sort of fatigue tests which duplicate the type of stress encountered in service.

For several years the writers have been performing a variety of tests on axles which are 2.75 in. outside diameter in the spline section. As was stated in a previous report by Knowlton (*Transactions* ⚙, 1937, page 260) it was found that the torsion fatigue test duplicated the *type* of fracture which occurred in service, but that static torsion and torsion impact did not. For other types of axles, bending fatigue tests more nearly duplicate service conditions. The present discussion will therefore be limited to the torsion fatigue tests, and the correlation between these tests and other types of tests.

Results of torsion fatigue tests on axles made of 11 different types of steel are assembled in Fig. 3. Included among these are two low carbon steels (4320 and 7028) which were carburized and hardened. The remaining axles were made of carbon and various types of alloy steels containing approximately 0.40 to 0.48% carbon, all heat treated for a surface Brinell of 321 to 388. Stress is plotted vertically and the number of cycles to failure horizontally. In each cycle the stress varied from zero to maximum in one direction.

In this type of test a certain amount of experimental error and scatter of results is unavoidable. Each type of steel is produced to a chemical specification which permits a range for the content of each of the hardening elements, and the hardenability and some of the other properties vary with the permissible analysis within a single specification. It is also necessary to allow a range of surface hardness produced by heat treating. Finally accuracy of machining and smoothness of finish have an effect on the fatigue results. Consequently each of the curves shown should certainly be a band rather than a line. In other words, these curves should not be taken too literally as representing absolute values of fatigue strength of the different types of steel. On the other hand the data do show some general trends of importance.

The value of fatigue curves in judging the usefulness of different steels depends largely upon the way in which they are read. Fatigue data are frequently expressed in terms of cycles of stress carried *at a given stress*, and if one specimen carries twice as many cycles as another, the former is reported as twice as good. This is far from the truth. Actually the first steel may have only slightly greater fatigue strength.

Table I — Typical Analysis of Axles Tested

Steel	C	Mn	S	P	Ni	Cr	Mo	Si	Grain Size	Normality
1046	0.45	0.68	0.029	0.024	....	0.03	....	....	3	Normal
4047	0.48	1.00	0.012	0.020	0.11	0.10	0.36	0.21	9	Slightly abnormal
4140	0.43	0.73	0.019	0.015	0.14	1.02	0.30	....	9	Slightly abnormal
4320	0.19	0.52	0.017	0.021	1.68	0.51	0.20	....	8½	Slightly abnormal
13T40	0.41	1.61	0.016	0.022	0.11	....	....	....	8	Normal
7028	0.30	1.04	0.023	0.020	0.07	0.07	0.24	....	8	Slightly abnormal
7045	0.43	1.02	0.011	0.022	0.14	0.05	0.41	....	9	Slightly abnormal
8442	0.45	1.41	0.016	0.021	0.08	0.07	0.37	0.21	9	Slightly abnormal
8245	0.48	1.33	0.014	0.023	0.14	0.06	0.16	0.22	8½	Normal
8744	0.46	0.90	0.029	0.023	0.52	0.56	0.23	....	8	Normal
9445	0.47	1.16	0.012	0.017	0.36	0.26	0.12	0.46	8	Normal

From a practical standpoint the engineer is probably more concerned with the stress which can be carried for a desired length of life. For example, if a vehicle is designed to last for 300,000 miles, an axle which fails in 50,000 miles is not much better than one which fails in 25,000. Neither gives satisfactory service. On the other hand, when the data are reported in terms of stress carried for a given number of cycles, it will be noted that the difference in fatigue strength between different steels is more reasonable, and the apparent error in tests on the same steel is relatively small: For example (referring to Fig. 3) in 4 tests of 4140 at a stress of 25,000 psi. the cycles varied from about 2.5 million to less than 5 million — an experimental error of 100% of the smaller number. However, in 6 tests of the same steel from 2 to 5 million cycles the variation of stress carried was only 23,000 to 25,000 — an experimental error of less than 10%.

Granting a possible experimental error of 10% in load carrying capacity, what do these curves show?

They seem to fall into three different zones, shown as hatched areas on the graph. These are described as regions of high strength, medium or average strength, and low strength (so far as torsion fatigue is concerned). However, even the lowest strength shown in the tests as plotted is above 18,000 psi., which is higher than the service stresses encountered by many axles.

The most remarkable thing about these data is that casehardened axles, made of two types of steel, definitely outperformed all of the axles made of full hardening steels! While casehardening may not be an economical method for the production of axles, the results do indicate some merit for axles which are quite hard on the surface and low in hardness in the center.

Various types of medium carbon alloy steel, including NE8744, NE8245, NE9445, and A4140, are found in the medium strength band. The steel originally used for these axles was 4140. Consequently any one of the first three NE steels should be satisfactory alternates, were it not that 8744 and 8245 have now been dropped from the list of standard specifications.

Peculiarly enough, the 1046 steel axles showed up as well or better than those made of alloy steel. It was noted however that these axles scarcely met the specified hardness on the finished surfaces. (These axles are heat treated as 3.125-in. diameter bars and machined after heat treating.) Considering the variation in hardenability to be expected with the variation of composition permitted by the specifications for 1046, it is very doubtful whether this type of steel could be safely recommended for this size of axle. The data do indicate the possibility of making a satisfactory axle steel by modifying the composition by the use of an "addition agent", thereby producing a little better hardenability.

The 13T40 axles seemed to fall at the low side of the medium strength band. In general there seemed to be some tendency for high manganese to lower the fatigue strength of the splined section. The 13T40 steel was a 1.61% manganese steel treated with Grainal. It is thought possible that the Grainal may have some effect in maintaining relatively good fatigue strength.

In or near the low fatigue strength band are found 8442, 7045, and 4047. 4047 and 8442 may be excellent steels for certain applications but do not appear to be as good as the other alloy steels for this type of axles. All three steels however are satisfactory if the service stress does not consistently exceed 18,000 psi., which is probably true for this particular axle.

The behavior of 7045 steel was the most erratic of any of the steels tested. Note that failures at 1,500,000 cycles range from 18,000 to 26,000 psi., whereas two others stressed at 21,000 and 23,000 ran for 5 and 3 million cycles respectively. This was a special steel developed by the writers' company as a substitute for 4140 before the NE steels were made. The analysis of the steel tested was carbon 0.43%, manganese 1.02%, and molybdenum 0.41%. Despite erratic behavior in testing, the relatively small number of axles made from this steel have given satisfactory service.

Correlation Between Fatigue and Other Tests

As fatigue tests are long and expensive we attempted to determine whether fatigue strength could be correlated with properties determined by short time laboratory tests, such as static torsion, tension, and impact.

Chemical Analyses — Typical analyses of the steels tested are shown in Table I, page 1107, and it would be difficult to rate their merit on the amount of alloying elements present. In general, high manganese and high molybdenum seem to reduce the notch toughness. (See Table II).

The 7000 series steels may need some explanation. As remarked above, this series was developed by the writers' company as a conservation measure before the NE specifications were created, and have since been discontinued. These steels are essentially manganese-molybdenum types. It will be noted that the 7028, which produced excellent casehardened axles, contained 1.04% manganese and 0.24% molybdenum — while the 7045 steel, which gave inferior results, had 1.02% manganese and 0.41% molybdenum.

P Value — The quality factor used by many metallurgists in the automotive industry and known as the "P value" was calculated from the tensile strength and reduction of area. The P value formula is as follows:

$$P = (T + 6R) \div 5$$

where T is the tensile strength in thousands of pounds per square inch, and R is the reduction of area in per cent.

The numerical values are shown in Table II, and the relative order of merit in each test is shown in Table III.

While all of these properties probably have some effect upon torsion fatigue strength, it will be readily seen that no one property can be used as a criterion for predicting fatigue strength. It is admitted that the relative rating of steels in the medium fatigue strength group is not definite. However no single property given in the table can be used for predicting whether a steel will have high, medium or low fatigue strength.

It is probably true, however, that a certain degree of each of several properties is essential to high fatigue strength. As will be discussed more fully in the following paragraphs, a certain amount of penetration of hardness is essential, but deeper penetration produces no higher fatigue strength. Similarly, a certain degree of toughness may also be essential, but greater toughness is of no merit in this service.

Hardenability and Cross Sectional Hardness — There has been a tendency lately to believe that the merit of alloy steels for torsion parts could be predicted from the hardenability. Figure 4 shows the Jominy hardenability curves of the steels used in the axle tests. By comparing the curves in Fig. 4 with those in Fig. 3 it will be seen that there is no positive correlation between the Jominy hardenability and the fatigue

Table II — Summary of Data From Different Tests

Steel	Torsion Fatigue Index *(a)*	Jominy Hardenability, 1/16 In. to C-45			Penetration				Static Torsion, In-Lb.			Impact, Axles		Impact, Min.	P Value Drawn at 600°
		Single Test	Min.	Max.	Near Surface	¼ R	½ R	At Axis	Yield Point	Ultimate Strength	Actual Surface Brinell	Ft-Lb.	Rockwell	Ft-Lb. *(b)*	
Group I — High Fatigue Strength (Casehardened Steels)															
7028	166	...	...	...	C-58	C-18	C-18	C-16	73,000	111,000	...	..	...	...	...
4320	160	...	...	...	58	23	21	17	79,000	122,000	...	..	...	...	...
Group II — Medium Fatigue Strength															
1046	130	...	2½	3½	C-35	C-35	C-35	C-32	68,000	119,000	302	3	C-22	...	...
8744	124	9	...	...	38	40	38	32	153,000	174,000	415	12	41	8.5	...
8245	120	6	...	...	37	35	31	30	128,000	171,000	401	18	36	4	165
9445	116	...	7	11	40	41	36	33	145,000	170,000	415	17	37	6	166
4140	116	...	10	30	35	33	33	29	99,000	133,000	341	36	33	9	196
13T40	107	5	...	...	35	33	28	24	99,000	143,000	331	24	35	4	163
Group III — Low Fatigue Strength															
4047	98	6½	...	...	C-33	C-27	C-24	C-22	82,000	102,000	311	33	C-32	7.5	166
8442	85	...	7½	28	36	35	35	32	113,000	158,000	351	29	36	7	166
7045	76	9	...	...	36	34	28	24	98,000	137,000	358	33	32	8	77

(a) Summation of fatigue strength for 500,000, 1,000,000, 2,000,000, and 5,000,000 cycles.
(b) Data on specimens drawn at different temperatures.

strength. NE8442 was one of the best steels from a hardenability standpoint, approximating the hardenability of 4140, but it was relatively poor in fatigue. Similarly the *penetration* of hardness in the finished axles is not a good criterion for predicting fatigue strength or service life. Hardness readings at ¼ radius and ½ radius did not show any correlation with fatigue strength. (However, it seems probable that at least some degree of penetration of hardness is necessary.)

If a part having no stress raisers fails in bending or torsion fatigue, the imposed stress should vary as a straight line function from a maximum at the surface to zero at the neutral axis. The strength at each point on the cross section is proportional to the hardness. It would seem logical that the strength at each point on the cross section should exceed the stress encountered at that point.

and the cross sectional hardness of these axles fell below the stress distribution line. One must not draw definite conclusions from two examples, but this seems to confirm the need for a certain minimum penetration of hardness.

Actually the axles under consideration fail in torsion fatigue at the roots of the splines, the locality of a stress raiser. Failure always starts at the surface. Judging from the comparison between fatigue strength of the axles compared with that of conventional rotating beam specimens, the root of the spline constituted a 3 to 1 stress raiser. The distribution of stress over the cross section of the splined axles is approximately as shown by the dash line in Fig. 5. While the exact shape of the stress distribution curve was not determined, it is evident that the properties of the layers near the surface are of maximum importance. Hardness and strength curves of

Table III — Comparative Order of Merit; Numerical Rating

Steel	Torsion Fatigue	Jominy Hardenability	Hardness Penetration				Static Torsion		Impact		P Value, Drawn at 600° F.
			Near Surface	¼ R	½ R	Center	Yield Strength	Ultimate Strength	Axles	Specimens	
					Group I — High Fatigue Strength						
7028	1	..	1	11	11	11	10	10	10 *(a)*	10 *(a)*	..
4320	2	..	1	10	10	10	9	8	10 *(a)*	10 *(a)*	..
					Group II — Medium Fatigue Strength						
1046	3	9	8	3	3	2	11	9	9	..	..
8744	4	3	4	2	1	2	1	1	8	2	..
8245	5	7	5	3	6	5	3	2	6	7	3
9445	6	5	3	1	2	1	2	3	7	6	2
4140	7	1	8	7	5	6	5	7	1	1	5
13T40	8	8	8	7	7	7	5	5	5	7	4
					Group III — Low Fatigue Strength						
4047	9	6	11	9	9	9	8	11	2	4	5
8442	10	2	6	3	3	2	4	4	4	5	1
7045	11	3	6	6	7	7	7	6	2	3	7

(a) Casehardened; actual value not determined but would be low, and steel therefore rated 10.

Figure 5, page 1111, shows the cross sectional strength of eight of the steels, as determined from the axle tests, in comparison with the theoretical stress distribution, based on a 2¾-in. diameter with no stress raisers. It is further assumed that the maximum surface stress cannot exceed the surface strength. The theoretical stress distribution is shown by a diagonal dotted line from a surface hardness of Rockwell C-34.

It will be noted that all of the curves with the exception of the casehardened axles 4320 and 7028 fall above the theoretical stress distribution line. Consequently all of these steels had sufficient hardenability. Higher hardenability in itself would not have produced higher fatigue strength. Two service failures have been reported, even the casehardened steels probably do not intersect this stress distribution curve.

While deep penetration of hardness may not be necessary to assure sufficient cross sectional strength, it is of maximum importance that the surface layers harden completely martensitic with a production quench. Incomplete hardening produces inferior mechanical properties. In very shallow hardening steels the properties of the surface layers after quenching and drawing may be inferior, even though the hardness is within the specifications.

Static Torsion does not seem to be a good test for selecting a new axle steel. It is however a valuable proof test to be used in production, to check on the heat treating operation.

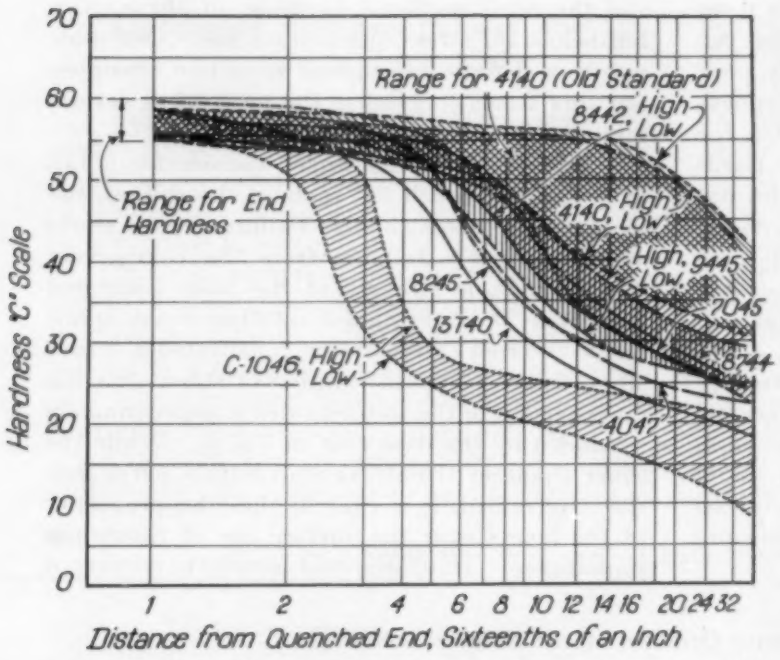


Fig. 4 — Jominy (End Quenched) Hardenability of the Eleven Steels Used on Axle Tests

Toughness — It is believed that toughness, particularly at high degree of hardness, is an important factor, even though it may not be a single criterion for the selection of steel. Jeffries and Archer in "Science of Metals" define toughness as the property of being difficult to break. Toughness involves both strength and plasticity. The function of plasticity is probably to permit a slight deformation in highly stressed areas, thereby producing a more uniform distribution of stress. The *amount* of plasticity necessary depends upon the design of the part and the type of service. If the design includes severe stress raisers, plasticity is of course desirable.

A number of formulas involving both strength and plasticity have been proposed as measures of "toughness", "quality", or "merit". While none of these may be scientifically correct, they do give some measure of toughness. In this article the P value has been selected.

It will be noted that, while the P values in Table II cannot be used to determine the relative merit in torsion fatigue, it is true that the steel which proved to be the poorest in torsion fatigue had a very low P value (77 at 600 draw). The other steels showed P values of 100 or higher. It seems probable that for any given design there is a *minimum* P value which is necessary, but very high P values may have no additional merit. It has been suggested that for most commercial parts a minimum of 95 to 100 may be correct.

As further evidence of lack of toughness, the 7045 steel, which gave the poorest and most erratic behavior on the torsion fatigue test, gave trouble with cracking during quenching; while 4140, a steel of slightly higher hardenability, did not. The surface of a large bar during quenching probably undergoes some deformation after it has hardened, and requires a certain amount of toughness. It has also been found that varying amounts of toughness are required in service depending upon the degree of stress concentration existing. It is believed that one of the merits of some of the old alloy steels was relatively good toughness at high hardness.

The impact test is a measure of notch toughness. The minimum degree of notch toughness required depends upon the sharpness of the notches imposed by the design. It was surprising to find that the very low figure of 3 ft-lb. for the 1046 axle did not cause it to fail at a low stress in torsion fatigue. This axle had involute splines with fair radius fillets. The results might have been different with straight side splines and poor fillets.

Internal Stresses — Probably one of the most important factors in the fatigue strength of finished parts is the internal stress in the surface layers produced by heat treating. This has been discussed by Almen in his recent series of articles in *Metal Progress*, and by Horger and Buckwalter in 1940 *Proceedings* of the A.S.T.M., page 733.

Almen states that all fatigue failures start as tension failures at the surface. Whether the internal stresses raise or lower the final fatigue strength depends on whether they are in compression or in tension. In his view residual tensile stresses aid in producing failure and consequently lower the apparent fatigue strength. Compressive stresses increase the fatigue strength, because the tensile stresses causing fatigue failure must first overcome the residual compressive stress before they can produce tension.

Whether the stresses produced by heat treatment are in tension or in compression depends upon the steel and the method of heat treatment. The problem is complicated, as a number of factors are involved.

During most of the cooling period produced by quenching, steel is contracting, but when it hardens to form martensite a dilation occurs. If a large part is drastically quenched the surface may become cold and hard while the center is still hot. If, later, the center hardens to form martensite, it should dilate and cause tension at the surface. On the other hand, if the center

fails to harden at all, the normal thermal contraction may produce compression at the surface. From this it would seem that a very deep hardening steel should always produce tension at the surface and, consequently, low fatigue strength.

The data given in this report indicate that this is not necessarily true. The problem is complicated by the fact that hardening transformations take place more slowly in the deep hardening steels. Frequently less drastic quenches are employed, and the difference in the time becomes less at which transformations occur at the surface and in the center.

In a very high hardenability steel, such as one which hardens in air, the speed of transformation may be so low that the whole section goes through the hardening transformation at the same time, and there should be little or no stress produced by heat treating.

Finally, the temperature and time of drawing have quite an effect upon internal stresses.

Further studies will be necessary before attempting to rate various types of steel with regard to types of stresses which may be produced by different heat treatments.

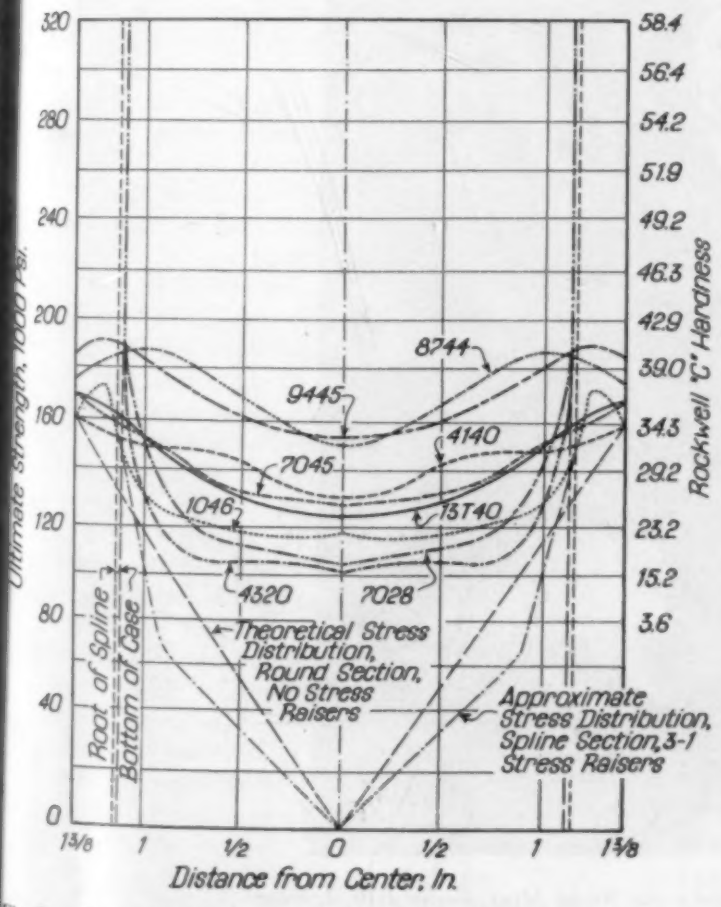


Fig. 5 — Cross Sectional Hardness (and Strength) of Axles After Heat Treating, Compared With Theoretical Distribution of Stress

Summary

In summary it may be stated that in most instances the present NE steels have proved to be satisfactory alternates for the former standard alloy steels.

It is difficult to judge the merit of a new steel on the basis of a *single* property, such as hardenability, impact strength or a quality factor. Hardenability has worked fairly well as a guide for the selection of *alternate* steels, but it has not been infallible. For example, in the axle tests reported herein, five steels selected on hardenability proved to be satisfactory alternates for 4140 but three did not.

Ideal steels are the least expensive steels from which can be made production parts which will give satisfactory service. Again it may be said that no single property is sufficient for the selection of an ideal steel. It is probably true that for any given article a certain minimum amount of strength, hardenability, toughness and other properties is necessary, but that greater amounts of strength and toughness may not increase service life. It follows, therefore, that before attempting to select ideal steels, individual parts or types of parts and service conditions to be encountered should be studied, to determine what minimum properties are necessary.

Hardenability and carbon content are good criteria for predicting surface hardness obtainable with varying sized parts and different quenching conditions. Strength of parts subject to uniform tension can also be predicted from the hardenability.

For parts subject to a maximum stress at the surface and zero stress at the neutral axis, the fatigue strength of the surface layers is of maximum importance. This depends upon the strength of the surface, the type of structure produced by quenching, the toughness of the surface both as quenched and after drawing, and the residual stresses produced by heat treating or by further mechanical treatment such as shot blasting or rolling. Residual stresses need further study. Some penetration of hardness may be essential, but the degree of penetration needed is probably less than usually supposed.

Finally it must be stated that design and machining finish may have a more pronounced effect on fatigue strength than the difference between properties of different alloy steels.

William Chandler Roberts-Austen, 1843-1902

Notable English Metallurgist

Assayer of the Royal Mint

Researcher and Scientist

Roberts-Austen, Standing at the Entrance to the Royal Mint, Tower Hill, London

Roberts-Austen Centenary

By Alfred Stansfield
Professor of Metallurgy, Emeritus, McGill University, Montreal, Canada

SIR WILLIAM CHANDLER ROBERTS-AUSTEN, born 100 years ago, was Professor of Metallurgy in the Royal School of Mines, and Chemist to the Royal Mint in London. He was an outstanding metallurgist whose work marks an epoch in the development of modern metallurgy, and his name has been perpetuated in the metallographic term "austenite". I had the privilege of being one of his students, and the further advantage of knowing him intimately and working daily in his research laboratory for seven years following my graduation.

Roberts-Austen learnt metallurgy from Prof. John Percy at the School of Mines, and was personal assistant for four years to the noted chemist Thomas Graham. He was associated most closely with the Mint, where he was Chemist and Assayer for 30 years. His residence was in the Mint, and he had a private laboratory there in which most of his scientific researches were conducted. The illustration on the opposite page shows him standing in the main entrance.

His position in the Mint gave him a practical interest in the metallic alloys used in coinage, particularly in the segregation that is found in silver-copper alloys, and in the effect of small amounts of impurity on the physical properties of coinage alloys. The great effect of "traces on masses" was one of his constant interests.

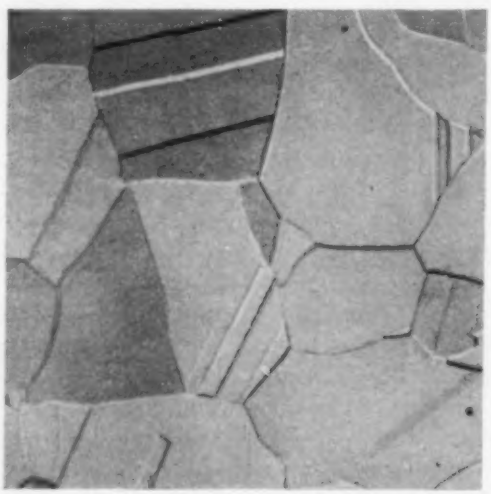
He wrote many papers for the scientific and technical societies in London and gave public lectures which were very effectively illustrated with experimental demonstrations. The British Institution of Mechanical Engineers became interested in his work, typified by the paper "Certain Mechanical Properties of Metals Considered in Relation to the Periodic Law", and financed the important researches on steel and other alloys which were carried on in the Mint during the last ten years of his life, and published in the *Proceedings* of the Institute in a series of six "Alloys Research Reports" from 1891 to 1904. Subsequent work along these lines was then transferred to the National Physical Laboratory, which had recently been established.

Based on Le Chatelier's thermocouple, Roberts-Austen devised his recording pyrometer which became a most effective instrument in these researches. A reflecting galvanometer, which was connected to a thermocouple, threw a spot of light on a moving photographic plate, and in this way a curve was traced which showed the cooling of the metal or alloy in which the thermocouple had been placed — any evolution of heat being shown by changes in the slope of the curve. The cooling curve of an alloy showed the initial solidification and also any transition points and eutectics, and by combining the curves for a series of alloys one obtained an approximation to the equilibrium diagram. The lead-tin, copper-tin, copper-zinc and other series of alloys were thus investigated, and to make these diagrams seem more "practical" for the mechanical engineers, the physical properties of the alloys were plotted on each diagram for comparison. Cooling curves of steel and cast iron were also obtained and these led to the production of the iron-carbon diagram and the solution theory of carburized iron.

A few years later, following the beautiful work of Osmond on the metallography of iron and steel, Roberts-Austen took up metallography (1895) and used it, together with the recording pyrometer, during the remainder of his researches. He showed, for example, the widely different microstructure of the same piece of steel after different heat treatments, and connected these differences with the thermal changes that had been shown by the pyrometer. He succeeded in introducing the microscope and the recording

pyrometer to English metallurgists and steel makers who were at first unwilling to admit that the allotropic changes in iron, shown by small inflections in a "cooling curve", could play any part in the hardening of steel, or that photomicrographs covering perhaps a pin head of metal could give evidence of any value regarding the properties of a large piece of steel. He was always interested in the work of the French metallurgists, especially F. Osmond's and Henri Le Chatelier's, and he introduced and interpreted their findings in England. In 1900 his Presidential address to the British Iron and Steel Institute was delivered at its meeting in Paris, and reviewed, appropriately enough, the advances in the art and science of steel making during the nineteenth century in France and England.

Roberts-Austen was interested in comparing the flow of solid metals under pressure with the flow of liquids, and in that connection he showed the resemblance between the "splash" of a steel plate when struck by a projectile and the splash of a liquid. A marble was dropped into a bowl of milk and the resulting splash was photographed at different stages by the instantaneous light of an electric spark. For poetic effect a golden bullet was also photographed falling into a dish of molten gold!



Roberts-Austen's duties at the Mint made it impossible for him to devote very much time to personal teaching at the School of Mines as Professor of Metallurgy, but he made up for this by his textbook, "An Introduction to the Study of Metallurgy", in which he subordinated the usual descriptions of smelting operations to careful statements of metallurgical principles and detailed accounts of the physical properties of metals and alloys. He included interesting particulars of his own researches with many references to the work of others.

In his public lectures Roberts-Austen frequently placed on the wall a long scale on which a spot of light, from a galvanometer, showed the temperature of a thermocouple which might be embedded in a piece of heated steel or a pool of molten gold; as the steel cooled, the spot of light would pause or even move backward at predicted points, showing evolutions of heat caused by molecular changes. He also showed an electric furnace in which metallic chromium could be melted, or silver boiled in the flame of an electric arc which was directed downwards by an electromagnet. A lens and mirror were arranged to project on a lantern screen a moving, colored picture of the melting and boiling metal. One of these lectures, at which I assisted, was given in Toronto at a meeting of the British Association for the Advancement of Science, and this led to my becoming a Canadian with a taste for electric furnaces. Roberts-Austen will long be remembered for the inspiration and practical help he gave to those who were associated with him.

The diffusion of metals was studied by him for several years; at first he measured the rate at which gold or silver would diffuse in molten lead, and later he was able to detect and even to measure the diffusion of gold in solid lead at room temperature.

Roberts-Austen had wide artistic and literary interests. He took great pleasure in the colors of metals and alloys, particularly in the "purple" alloy of gold and aluminum, discovered in his laboratory, in which the two metals combine to form a definite chemical compound with a melting point that is higher than that of pure gold. He was largely responsible for the patination or coloring of the "bronze" medals made in the Mint from time to time. He was associated with the erection and decoration of a village church, near his country home in Surrey, where he frequently conducted the services as a diocesan reader. His literary care and skill are shown in all his addresses and in his metallurgical textbook.

A very good sampling of his metallurgical papers was collected by his associate at the Mint, Sidney W. Smith, and published in 1914 by Charles Griffin and Co. of London under the title "Roberts-Austen — a Record of His Work". This may be consulted with profit by any metallurgist. Mr. Smith also took "The Life and Work of Sir William Roberts-Austen" as the topic of a Centenary Lecture before the Institution of Mechanical Engineers in London; the text appeared in *Metallurgia* for March 1943. Roberts-Austen's own book "An Introduction to the Study of Metallurgy", is a classic; it was published in London by Charles Griffin & Co. in 1891, and ran to five editions, the last appearing in 1903.

Research Instrument

A New Type of Recording Dilatometer

By W. E. Kingston
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IN OUR investigation of low expansion alloys for glass-to-metal seals, we have made many hundreds of expansivity measurements of metals, alloys, and glasses. In order to obtain the extreme accuracy necessary for this type of work, we originally used a concentric quartz tube dilatometer similar to that described by the Bureau of Standards and in use in many laboratories. A sensitive, calibrated dial gage indicated the linear expansion of the specimen, and a Leeds and Northrup Type K potentiometer measured the temperatures.

While this equipment, when carefully operated, is quite accurate, constant attention of a skilled technician is necessary and the plotting of elongation-temperature curves is laborious. Another objection is that it is impossible to make readings fast enough to follow the true changes in length of specimens which undergo rapid changes in expansion or exhibit anomalies in elongation as a function of temperature, such as ferrous alloys at thermal critical points.

With the above in mind, we attempted to purchase a recording dilatometer which would be sensitive and accurate enough for our purpose and which would automatically make a continuous record, but no equipment could be found which would fulfill our requirements. We therefore attempted to develop one and after considerable investigation arrived at a design which was satisfactory in every way.

We started from a basis of the concentric quartz tube principle, which is second to none insofar as accuracy is concerned. The improved indicating dilatometer is shown in Fig. 1. The automatic recording dilatometer uses the same furnace, concentric quartz tube, and dial gage. Figure 2 (page 1116) shows the complete automatic recording dilatometer. This recording dilatometer records directly on a paper chart. The chart is linear; the record is in ink. The working range for expansivity can be varied at will. The working range chosen as most desirable for our purposes (study of low expansion alloys) gives a vertical movement of 20 in., equivalent to an expansion in the specimen of 0.030 in. The temperature spread is 12 in. This

Fig. 1 — Improved Indicating Dilatometer

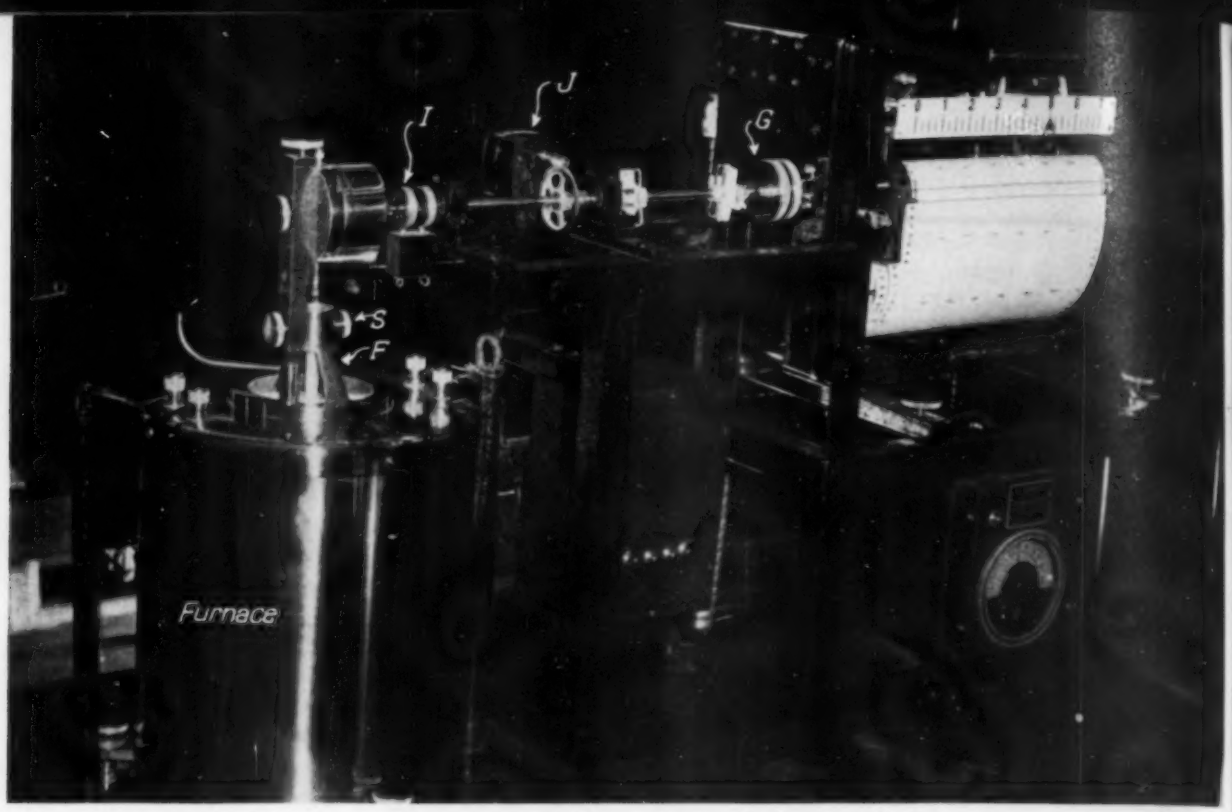


Fig. 2 — Assembled Equipment; Furnace, Recorder, and Drive Between Dial-Gage Pointer and Chart Drum

recording dilatometer therefore draws a curve which is identical to the curve calculated from an infinite number of dilation vs. temperature readings on the dial gage of a concentric quartz tube dilatometer. No attention is required other than inserting the specimen in the dilatometer and starting up the equipment. At the end of our standard 8-hr. run (4 hr. heating and 4 hr. cooling) the equipment is shut down and the chart constitutes a complete record of the expansion and contraction of the specimen.

In the apparatus there are six principal functions, each performed by a separate unit, all of which are closely coordinated. These are:

A. Furnace (or sub-zero cooling chamber)
B. Concentric quartz tube
C. Dial gage standard and dial gage
D. Contact mechanism
E. Transmission shaft
F. Recorder
G. Electronic relay

Each will be described briefly. The furnace (also shown in Fig. 1) consists of a 12 by 12-in. stainless steel shell mounted on leveling screws. The removable cover contains a hole in which rests the dial gage standard. The heating element consists of coiled nichrome wire wound on the outside of a grooved alundum tube. (Helical windings compensate for end losses by spacing the individual turns closer together at both ends of the core.) Around this hollow alundum core and supporting it is 2½ in. of insulating refractory brick (B & W-K28) next to the heating element, and 3 in. of Sil-O-Cel insulating brick on the outside. Inside the core is placed a copper block 2 in. diameter and 8 in. long which has a ⅝-in. hole running along its principal axis.

Through the copper block, midway between the inside and outside diameters, are drilled eight ¼-in. holes the complete length of the jacket, evenly spaced around the block. By undercutting each end of the block all of these holes are connected in parallel. Into each undercut section is swaged a monel head in which is brazed a ¼-in. nickel tube. One of these tubes projects through the top of the furnace and the other through the bottom. This system is used for a stream of hydrogen, for regulating the cooling rate. (Before assembly, the copper block was heavily plated with chromium inside and out and this plating firmly alloyed with the base metal by heat treating; the purpose being to prevent excess oxidation of the copper at high temperatures.)

Pressed into the bottom of the central hole in the copper block is a small nickel tube which also extends through the bottom of the furnace. This latter is used to admit various atmospheres around the specimen, as desired.

The copper block establishes considerable thermal capacity around the specimen and gives uniform temperature distribution to within 1° C. along the 5-in. specimen over a temperature range between 70 and 850° C.

The metal specimen (*E*, Fig. 3) is 5 in. long, 0.10 to 0.25 in. diameter, and has studs 0.040 in. diameter at each end. (Glass specimens are of the same length but have rounded ends.) Midway between ends is drilled a 0.030-in. hole for

Fig. 3 — Specimen E Fits Loosely in Outer Quartz Tube A and Rests on Quartz Plug D. Length change is transmitted by movements of quartz tube C

the thermocouple. The outer concentric quartz tube (*A*, Fig. 3), which is held firmly by the dial gage standard, has sealed in its lower end a drilled quartz plug *D*, against which the bottom end of the specimen rests. The centering stud fits loosely into the hole in the plug, which also admits the desired atmosphere. The face of this plug is ground optically flat, as is also the bottom face of the inner quartz tube *C*, which transmits movement of the specimen to the dial gage. The outer quartz tube has an outside diameter of about ½ in. The inner quartz tube is centered by small quartz spacers melted into the tube, and making a loose fit.

The thermocouple, which is made of 0.010-in. wire, is pulled through the hole in the specimen where the hot end is tightly wedged. Both wires then extend vertically between the quartz spacers, and are wound in a helix around the inner quartz tubes, being securely fastened to the extreme top of the inner tube by a rubber band.

The standard (*F*, Fig. 2) supports the dial gage and adjustments as well as the quartz tube assembly. All important parts of this standard are made of Invar (36% Ni, 64% Fe) in order to minimize errors due to extraneous thermal gradients. The quartz tube assembly is clamped by a brass keeper which is forced by spring action against one side of the outer tube. The spring action is only strong enough to hold the quartz tube assembly securely in place. The knurled screw *S* serves to unclamp the keeper and release the quartz tube assembly, and has no function as a clamping adjustment.

The dial gage is a specially selected and calibrated Starrett gage having stainless steel parts and jeweled bearings. One revolution of the pointer is equal to 0.010 in. To the gage is fastened an Invar slider, so that its vertical position is adjustable.

When used as an indicating dilatometer, the dial face is not altered and readings are taken directly from the scale. When used with the automatic recorder the scale is removed and a small platinum flag is soldered to the end of the pointer, serving as the common pole in a single-pole double-throw switch, which is grounded through the dilatometer and furnace shell, from where it is electrically connected to the electronic relay.

Figure 4 shows the contact mechanism which is placed on the end of the transmission shaft leading to the recorder at the right. This stainless steel shaft is pointed and extends to within $\frac{1}{16}$ in. of the dial pointer shaft, and is held so it will not move horizontally by collars which are placed on each side of one bearing. (A second section of stainless steel shafting connects to the recorder with universal joints to correct slight misalignments.) The clutch *G* is engaged or disengaged by a slight turn of the knurled knobs; its purpose is to rotate the chart drum free of the balance of the transmission shaft.

The contact mechanism of Fig. 4 consists of a bakelite block attached to the horizontal shaft. On opposite sides of this block are placed light phosphor bronze springs *H-H* having platinum contacts on their extreme ends, adjustable within

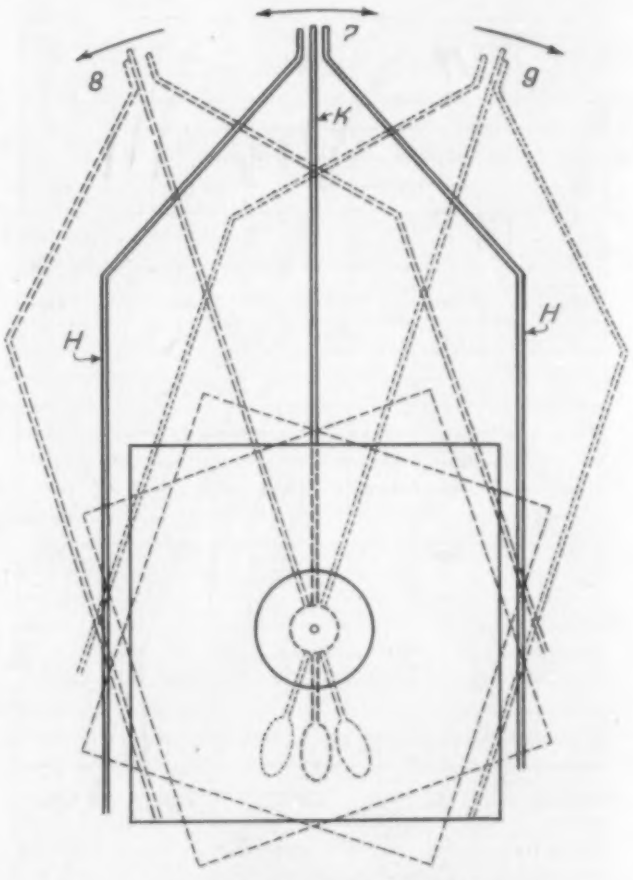
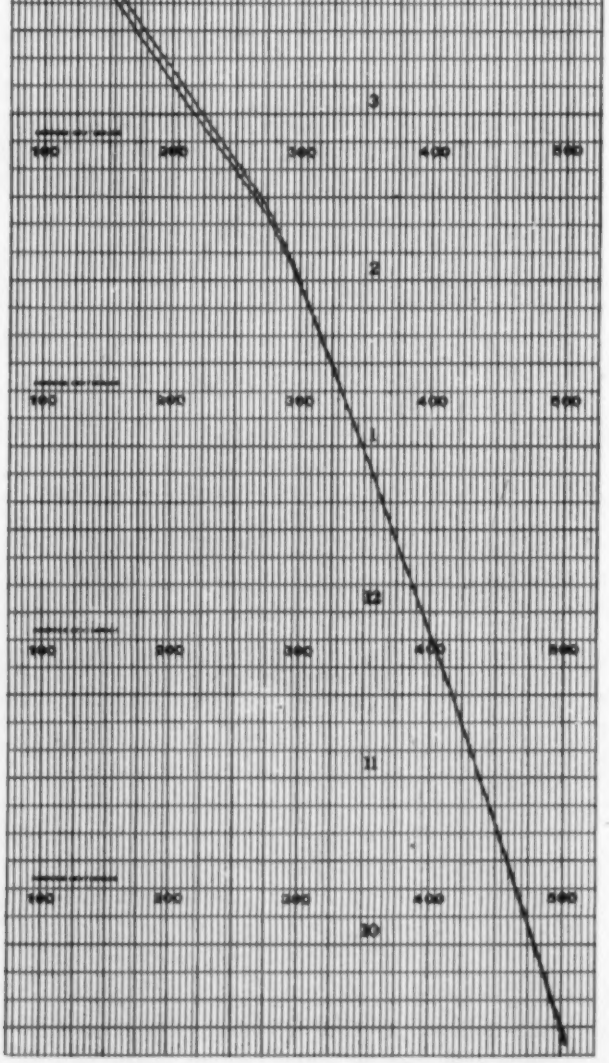


Fig. 4 — Detail Showing Action of Contact Mechanism on Dial Pointer. One complete revolution of pointer equals 0.010 in.

a few thousandths of an inch apart. In actual use this contact assembly is positioned so that the platinum flag on the dial gage pointer is between the contacts at the ends of *H-H*, and all are free to rotate in the same plane and through the same great circle. Leads from *H-H* terminate at slip rings *I* (Fig. 2), which are silver plated brass rings mounted on a bakelite core, and contact silver graphite brushes which transfer the electrical circuit to the electronic relay.

This electronic relay simply amplifies the current originating at the contact mechanism from a few millionths of an ampere, to approximately 100 milliamperes, which is adequate for the magnetic relays, operating a small, dynamically braked reversible motor *J* (Fig. 2) which drives the transmission shaft. The functioning of this driving arrangement will be explained subsequently.

Fig. 5 — Heating and Cooling Curve of Low-Expansion Alloy Run in Air; Lack of Identity at Lower Temperatures Is Due to Oxidation Effects



The recorder is a standard recording potentiometer pyrometer controller, whose time drive mechanism has been removed, allowing the chart drive roll to rotate freely. By means of an extension shaft, the chart drive roll is connected directly to the horizontal shaft on which is fastened the contact mechanism. Therefore the chart drive roll follows directly the movement of the dial gage.

In actual operation the following procedure is used: First, the thermocouple is threaded through the specimen. The quartz tube assembly is then placed in the standard and clamped in place. The standard is then placed in position on the furnace and the thermocouple leads connected to their proper terminals. Next, the dial gage is clamped securely in position so that the axis of its pointer and the pointed end of the transmission shaft coincide. During this latter operation the contact mechanism is slid back out of the way. The quartz tube assembly is then raised so that the recessed end of the inner tube comes in contact with the pointed thrust pin on the dial gage. With metal specimens, the quartz tube assembly is then raised some 0.001 in. further, causing the dial pointer to rotate and putting a definite pressure on the inner quartz tube and specimen. The contact mechanism, whose contacts had previously been set some 0.005 in. apart, is then moved into position so that the flag on the dial pointer is between the two pointed platinum contacts. Thus any movement of 0.002 in. of the dial pointer in one direction or another from neutral will complete one circuit or the other. The contact mechanism is then clamped in place. The clutch is then released and the chart set with the pen on one of the major abscissa (time axis) of the chart. The relay power is then turned on and the relay and motor drive the transmission shaft to the neutral position. (This is desirable since it is difficult manually to set the contact mechanism in exactly the neutral position.) The clutch is then locked in this position.

The recording dilatometer is now ready for use. The program control is set for the proper rate of temperature increase and decrease, and the auxiliary maximum temperature adjustment set to the desired value on the recording potentiometer controller. We usually use a uniform heating rate of 100° C. per hr., both for heating

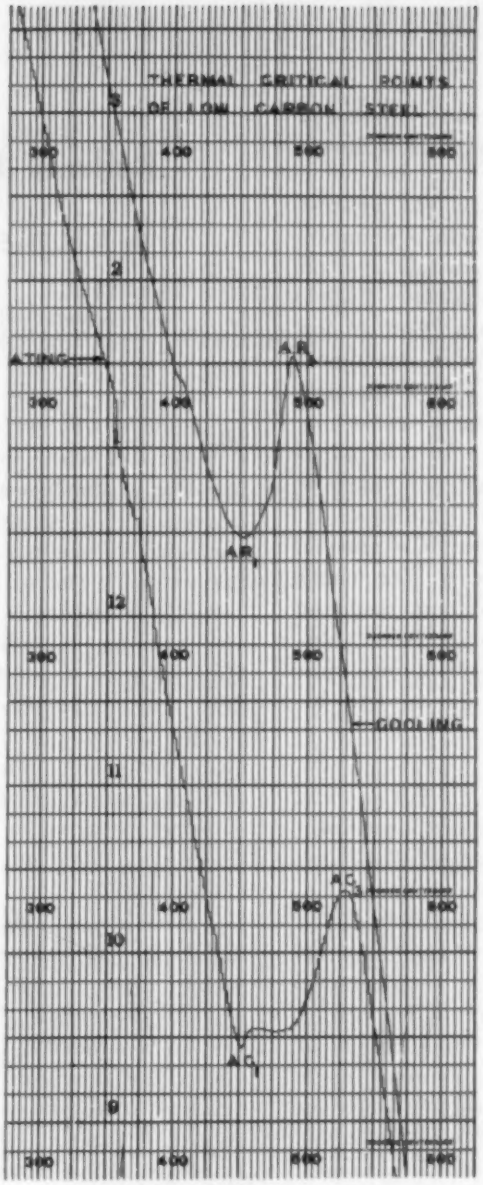


Fig. 6 — Transformation Points Clearly Shown by Expansion Characteristics in S.A.E. 1020 Steel (Temperature Scale Displaced)

and cooling, and for low expansion alloys the maximum temperature setting may be 500° C. In our set-up the cooling cycle automatically follows the heating cycle, no manual switching being necessary. The hydrogen flow is adjusted through the copper furnace jacket to a value of about 5 cu.ft. per hr., the gas being ignited and burned at the end of vent.

The power switch is then turned on, and no further attention is necessary until the record is complete. Its accuracy is many times that of the standard, visually read, concentric quartz tube dilatometer. It can follow sudden changes in rates of expansion or contraction, or reversals in slope, practically instantly.

A brief explanation should be given of the operation of the important contact mechanism, relay, drive motor and the transmission shaft. Referring to Fig. 4 (page 1117), the starting or neutral position is shown as position 7. As the specimen is heated and expands, this movement is transmitted through the inner quartz tube and the dial thrust pin, and the dial pointer *K* turns slowly in a clockwise direction until it makes contact with *H* as shown in position 9.

This movement is at most 0.002 in. Since one revolution of the 4-in. diameter gage corresponds to 0.010 in. expansion (or contraction), and 1 in. movement of the pointer equals 0.001 in. expansion, then 0.002 in. movement will correspond to an expansion (or contraction) of 0.000002 in. of the specimen. This gives an indication of the sensitivity of the instrument.

After contact as at 9, the relay closes the motor circuit causing it to drive the entire contact mechanism *D* in a clockwise direction until the contacts re-open. As there is practically no inertia to the system there is no overswing. The motor itself is a synchronous type whose rotor runs at a speed of 1800 r.p.m. and is geared down to 0.7 r.p.m. The rotor can stop within a 180° turn and the transmission shaft can follow exactly any minute variations of the dial.

In operation the contact mechanism and also the recorder chart drum follow the dial pointer through a series of infinitesimal steps, and in so doing move the chart

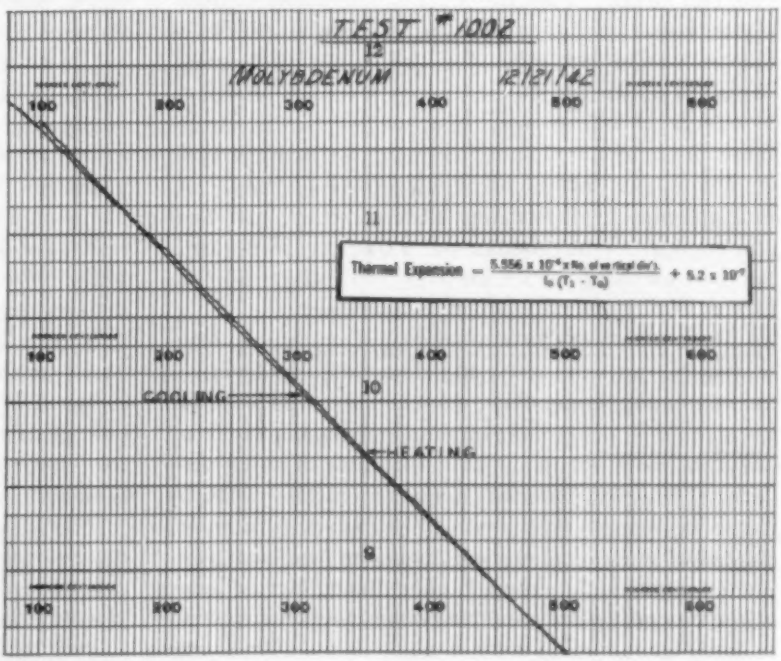


Fig. 7 — Expansivity of Molybdenum Measures 58.0 × 10⁻⁷ From This Chart, 0.2% Higher Than National Bureau of Standards' Value for This Metal

paper in accordance with the actual expansion and contraction of the specimen — although greatly magnified.

When the specimen contracts, the reverse takes place, the dial pointer turns in a counter-clockwise direction and the other contact arm on the contact mechanism is engaged as at 8, Fig. 4, driving the motor and transmission shaft in the reverse direction. In short, with this equipment, the contact mechanism is free to follow the dial indicator pointer, regardless of the direction or speed of rotation or number of revolutions without appreciably loading the dial gage pointer or impairing the accuracy of the gage readings.

The calibration of such equipment is simple, knowing the exact circumference of the chart drive roll, the length of the specimen, and the value (in thousandths of an inch) of one revolution of the dial gage. The following equation gives the thermal expansion A in in. per in. per °C.:

$$A = \left(\frac{c \cdot n}{L_o \ (T_1 - T_o)} + 5.2 \right) \times 10^{-7}$$

where c is the circumference of chart drive roll in inches, n is the number of vertical divisions, and L_o is the length of specimen.

Typical expansivity curves are reproduced on the preceding pages. An idea of the sensitivity of the measurement is obtained when one considers that the actual width of the chart between 100 and 500° C. is 7 in. One chart is of a low expansion alloy for glass-to-metal seals with expansivity of 90×10^{-7} per degree between zero and 400° C. The heating and cooling curves are both shown clearly. In this case the specimen was run in air. Had an inert or reducing atmosphere been used around the specimen the two curves would coincide, for the slight difference is due to oxide which increases its length slightly. The second curve was run on an S.A.E. 1020 steel, and shows the thermal critical points clearly. The third (heating-cooling curve of molybdenum) illustrates the accuracy of the equipment. Our measured value is 58.0×10^{-7} per ° C., as compared with 57.9×10^{-7} given by the Bureau of Standards for the same range.

In conclusion, this mechanical system simply transfers, continuously, the accurate readings of an indicating concentric quartz tube dilatometer to a chart where expansion or contraction is automatically recorded as a function of temperature. Thus the inherent accuracy of the indicating dilatometer is preserved. The accuracy of this equipment is believed to be on the order of ± ¼%, which is much higher than that of any other recording dilatometer with which the writer is familiar.

Railway Bearing Metals

By J. N. Bradley and Hugh O'Neill

(Abstracted from a 1942 paper for the Institute of Metals)

A RAILWAY organization may require 1500 tons of white metal per annum for bearings. In view of the present scarcity of tin, the particulars of a study comparing lead-base and medium tin-base alloys will be of interest in connection with the utilization of national supplies.

While determining the properties of standard bearing metals specified by the London, Midland & Scottish Railway Co., it was observed that specimens whose strength is undermined by the presence of a lead-tin eutectic creep most under pressure. The lead-base alloy (75% lead, 13% antimony, 11% tin and 1% max. copper) is therefore superior in this respect to the bearing containing 60% tin, 10% antimony, 4% copper, balance lead. Also it offers better resistance to repeated impact, though both have about equal resistance to pounding. Unfortunately, the former alloy is much more prone to segregation in thick bearings. Lead-antimony-tin alloys are said to wear better than the tin-antimony-copper alloys, but they run a little warmer. Apart from dangers of admixture in reclamation and casting shops, it appears that lead-base alloys could be employed to a considerable extent for railway work, particularly in the absence of hammering stresses and heavy loads.

All engineers are anxious to obtain good bonding between the anti-friction metal and the bearing shell, for inferior adhesion is said to lead to excessive stresses in the white metal, and liability of hot boxes.

For inspection purposes an impact adhesion test was introduced by the L.M.S. Railway in 1935 which measures the energy required to detach the layer of white metal from prismatic test pieces machined from the actual bearing. The test should yield an average impact adhesion value of 23 ft-lb., which is equivalent to 30 ft-lb. per sq.in. Very good bonds cannot be broken; the shoe actually shears through the alloy rather than breaking it away from the bronze.

Where the impact adhesion test would mean the destruction of a large bronze casting, another procedure has been devised. This consists of shaping away some of the lining to leave 1-in. square projections, *(Continued on page 1144)*

Emergency Metallurgy in Germany

German Emergency Steels and Their Treatment in Salt Baths

By C. Albrecht
Translated from "Schweizer Archiv" for October, 1942, by E. I. Valyi

STEELS containing nickel have almost disappeared in Germany in the last few years. The first substitutes were chromium-molybdenum, but these were later abandoned in favor of the chromium-manganese steels (sometimes fortified with silicon). The attached tables show the analyses and physical properties of steels now widely used. [EDITOR'S NOTE: Two American steels somewhat similar to two of the German steels are included; ideal hardenability, computed by Grossmann's method, is also given.]

Heat Treatment — The chromium content in the absence of nickel imparts certain properties to the steels that have to be watched: They scale and decarburize more readily; they are increasingly susceptible to overheating and uneven timing cycles. Excess massive retained chromium carbide may appear in the carburized case, particularly with comparatively deep cases, with an adverse influence on the mechanical properties.

Tensile Strength of Carburizing Grades, as Hardened, Range in 1000 Psi.

DIAMETER OF BAR	EC 80	EC 100	EC-Mo 200
10 mm. (0.394 in.)	157-200	200-242	—
20 mm. (0.787 in.)	135-171	171-220	—
30 mm. (1.18 in.)	121-157	157-205	171-214
60 mm. (2.36 in.)	—	—	157-200
90 mm. (3.54 in.)	—	—	142-185

Tensile Strength of Quench-Hardened Steels, Range in 1000 Psi.

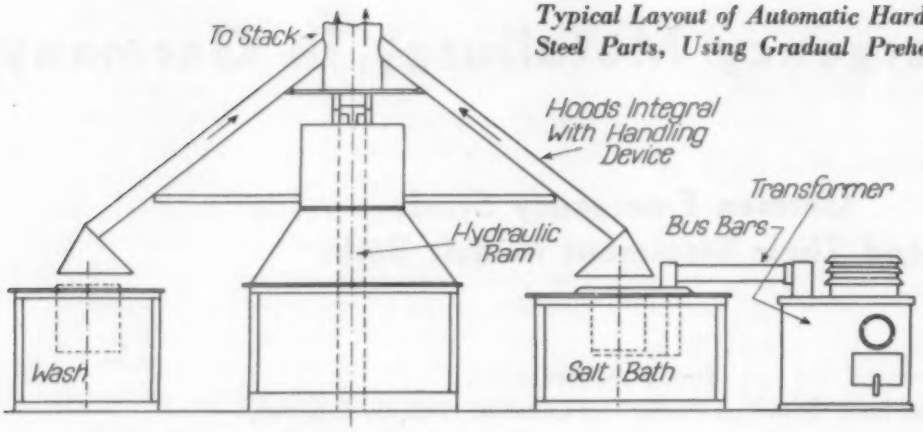
DIAMETER OF BAR	VM 125	VMS 135	VMC 140
60 mm. (2.36 in.)	93-114	114-135	135-157
100 mm. (3.94 in.)	93-114	107-128	128-150
150 mm. (5.90 in.)	85-107	100-121	114-135
200 mm. (7.87 in.)	85-107	93-114	114-135

Emergency Steels Made in Germany
Nearest comparable American Steels shown in italic lines

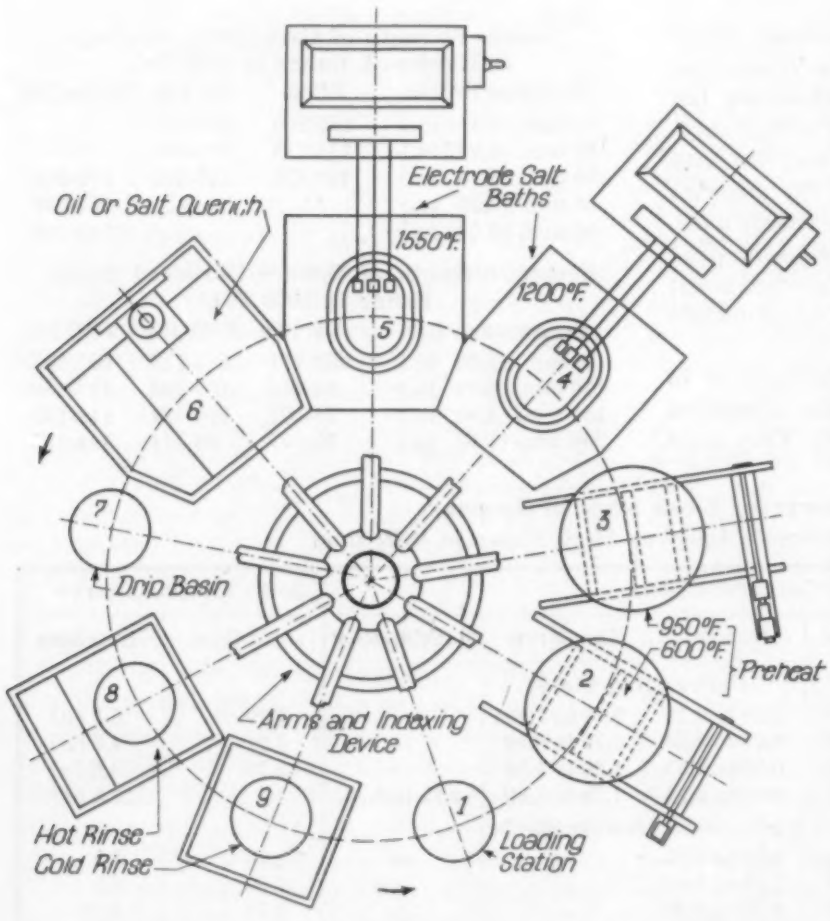
TYPE	CHEMICAL LIMITS					IDEAL HARDENABILITY*	
	CARBON	MANGANESE	SILICON	CHROMIUM	MOLYBDENUM	LOW SIDE	HIGH SIDE
			Carburizing Steels				
EC 80	0.12 to 0.17	1.10 to 1.40	0.20 to 0.35	0.80 to 1.10	—	1.70	6.1 *(a)*
S.A.E. 5120	*0.17 to 0.22*	*0.70 to 0.90*	*0.20 to 0.35*	*0.70 to 0.90*	—	*1.21*	*4.1 (a)*
EC 100	0.18 to 0.23	1.20 to 1.50	0.20 to 0.35	1.20 to 1.50	—	2.70	8.0 *(a)*
EC-Mo 200	0.17 to 0.23	1.20 to 1.50	0.20 to 0.35	1.70 to 2.00	0.15 to 0.25	4.0 *(a)*	13.5 *(a)*
			Quench-Hardening Steels				
VM 125	0.28 to 0.35	1.20 to 1.50	0.20 to 0.35	—	—	1.20	3.5
VMS 135	0.35 to 0.40	1.10 to 1.40	1.10 to 1.40	—	—	1.93	5.5
NE 9255	*0.50 to 0.60*	*0.70 to 0.95*	*1.80 to 2.20*	—	—	*2.03*	*3.73*
VMC 140	0.35 to 0.43	1.00 to 1.30	0.50 to 0.80	1.00 to 1.30	—	2.65 *(a)*	11.*(a)*

*Columns added; computed after assuming current limits of tramp alloys present; fine grain steels on low side of analysis and vice versa.
(a) Approximate, on account of probable undissolved carbides.

Difficulties with regard to decarburization, scaling and susceptibility to slight changes in the heat treating cycle have been controlled by the use of salt baths. Carburizing is also successful in correct salt baths. Salt bath carburizing to a heavy case can be followed by a diffusion treat-



Typical Layout of Automatic Hardening of Intricate or Spindly Steel Parts, Using Gradual Preheat and Interrupted Quench



ment, thus controlling the carbon content of the case. Extraordinary accuracy can be achieved this way with regard to carbon distribution.

All the baths used [presumably in the author's plant, Degussa, in Frankfurt am Main] are of the cyanide type, both for carburizing and for hardening and drawing, and the cyanide content has great influence on the type of the furnace.

Salt Baths — All the furnaces contain electrodes placed very close to the container wall and the current passes between electrodes and pot. The rest of the bath available for work is practically free of electric flux, so the current input remains practically constant even if work of very sizable dimensions is charged. The electrodes are preferably closely spaced along one of the longer walls of rectangular containers, which gives a uniform temperature distribution and appears to avoid trouble with the cyanide baths, even if they are operated at temperatures not much below the decomposition temperature. Transformers are placed close to the furnace, and supply current at 8 to 16 volts. Automatic controls will maintain temperature within $\pm$ 2° C. or at most 3° C.

Such furnaces with steel pots up to 6 ft. in depth have been built and operated successfully. The crucibles last for 3000 hr. of continuous operation at 1700° F.

Heat Treating Cycle — These emergency steels may be hardened from near 1600° F. Quench and draw at 600 to 900° F., as required. Whereas carbon steels are quenched in water or oil, these emergency alloy steels are quenched in oil, although quenching in molten salt at approximately 400° F. shows great advantages over oil quenching, since it reduces cracking and warpage about 50%. At the start such a quenching bath would be heated electrically or by immersion gas-fired tubes; the temperature increase due to intake of hot work is compensated for by cooling (by air, in the case of small furnaces, and by water jackets in the case of larger furnaces).

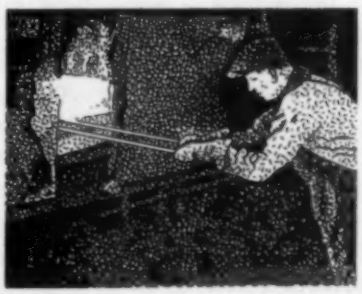
In addition to the salt quench furnaces, air convection type preheating furnaces are also used, bringing the work to 500 to 800° F. prior to transfer into the hot salt bath maintained at quenching temperature.

The plan shows an arrangement for automatic hardening. Station No. 1 is for unloading

and loading the fixtures. Station No. 2 is occupied by a preheating furnace, having a fan below the work basket circulating the air through the work and over electrical resistors. The furnace has capacity for three loads and work is brought up to about 600° F. in 30 min. Station No. 3 is a similar furnace operating at 950° F.; the two of them give generous time for preliminary heating, necessary for gradual stress relief and avoiding warpage. Station No. 4 is an electrode salt bath operating at about 1200° F., holding a single fixture for 10 min., and Station No. 5 a second furnace operating at the correct hardening temperature (say 1550° F.). One of these furnaces can be eliminated if comparatively small and simple work is to be handled in relatively low tonnage; mass production on 10-min. cycles and minimum warpage in finished work would indicate the use of two furnaces, however. Station 6 is occupied by an oil quench tank (or a molten salt bath, if interrupted quench is preferred). Station 7 is a drainage pit, and Stations 8 and 9 are hot and cold water rinse, respectively.

A similar layout is used for tempering, but in this case three units take the place of Units 2 to 6 in the hardening circle. First is an air convection furnace, preheating a load to approximately 700° F. in 30 min. Next is an electrode salt bath for drawing, operating at, say, 950° F. Third is a salt pot with submerged heater, containing a very fusible salt into which the tempered parts are immersed for rapid cooling (thus avoiding "temper brittleness" and protecting the surface during cooling). Finally are the hot and cold rinses. Time at each station would be about 30 min.

In both quenching and drawing circles the work is carried by a rotary mast, the arms from which also contain the exhaust ducts for rising vapors. The work, held in baskets or fixtures, is moved by lifting, turning and lowering of the mast, which is controlled automatically by an electric timer.



Great uniformity of structure and hardness as well as dimensional precision can be achieved. Changes in dimensions are reduced to a minimum and remain uniform for all pieces; therefore, they can be reckoned with in designing. The method here described results in improved wear resistance in gears.

Carburizing is also carried out in salt baths at 1700° F., lasting from one to six hours depending upon case depth required. In 3 hr. a case 0.050 in. deep (the hardened rim measured on a quenched and fractured piece) can be produced; in 6 hr. the depth is 0.070 in. In a long heating cycle, massive chromium carbides appear in the case of these emergency steels, as above mentioned, but if the case does not materially exceed 0.040 in., these carbides do not cause much concern. With increasing depth, it may be necessary to diffuse them by further heat treatment in another neutral salt bath of special composition held at carburizing temperature.

After carburizing, the work is quenched, preferably in salt as above described. Subsequently, the work is hardened at approximately 1500 to 1550° F., followed by final quench in a salt quench. Frequently a second hardening at a lower temperature, for the core, is specified. The complete hardening cycle is done in a circle, exactly as outlined above for the quench-hardened steels. Due to the long carburizing period, either with or without diffusion, automatic devices such as shown in the figure are hardly practical except when very large quantities of work are handled.

"Emergency" High Speed Steels — In the emergency high speed steels, the alloying constituents were considerably reduced. After some use of tungsten-molybdenum steel, the following low-tungsten composition was arrived at:

Carbon	1.35%
Vanadium	4.30
Chromium	4.25
Tungsten	11.50
Molybdenum	0.90

This steel is more susceptible to differences in heat treatment than the steels previously used, and also shows greater tendency to decarburize. All such difficulties were overcome by the use of salt baths. A commercial compound known as "Carbo-Neutral" has proven suitable.

Quenching is done from about 2375° F. after heating in a high temperature electrode furnace, refractory lined. The cycle is best carried out by preheating 30 min. to 750° F. in an air-convection furnace, further preheating 30 min. up to 1650° F. in a salt bath furnace containing salt melting around 1300° F. Then comes the high heat for hardening (just long enough to be heated through, followed by quenching in a salt bath at 1076° F. (salt melting at approximately 800° F.). After air-cooling that follows, the steel is drawn once or more for 30 min. in the last mentioned "quenching" bath. This method of heat treating is generally used and eliminates decarburization, cracks and undue warpage.

Metallurgicus' Own Page

(An A. S. M. Book of Your Choice for a Publishable Item)

A PREVIOUS DISCOURSE was devoted to the desirability of fully quenching steel ("Quench Out", July 1943) in which it was pointed out that *uniform* hardening is helpful in reducing distortion. The benefit of the Gleason or Gogan press in this respect is probably due far more to the uniformity of application of the quenching oil than to any holding or gripping.

The principle of press quenching or die quenching can be applied easily to many kinds of parts totally unlike the gears for which such equipment is usually used. A common example is leaf springs. For hardening other thin, flat parts such as washers, quenching in dies has great value; pieces can be hardened uniformly and brought out respectably flat. (The word "respectably" evades a forthright statement of *how flat*, but quenching in dies will make them flatter than any other way I know of.)

Dies for such parts are very simple — the usual shop term "waffle dies" describes their appearance. Upper and lower dies are hollow, usually made of iron castings or welded steel, and the working faces are cross-ground or channelled say ⅛ in. deep so that high spots about ⅛ to $\frac{3}{16}$ in. square are left between grooves. Small holes, about $\frac{1}{16}$ in. diameter and ¼ in. apart, are drilled in the grooves, and pass quenching liquid through from the chamber behind the face. In use, one die, usually the lower, is fixed and the other carried on the ram of an air or hydraulic cylinder, or even by a mechanical linkage. Quenching water or oil is fed into the hollow chambers of both dies, so that it squirts out of the small drilled holes with high velocity.

In actual use the washers are heated in a box furnace and brought out one by one for quenching, placed on the lower die (no quench flowing), and the upper die brought down on top of it. A foot pedal is a convenient way of actuating the die movement. Then the quench is turned on with pressure of at least 15 psi. The valve may be linked with the die travel so it opens at the proper time. Quench time will be much shorter than in open tank quenching, and the washer will come out surprisingly flat.

One important point: Be sure *both* dies drain after each quenching cycle, else one will start flowing sooner than the other. The piece will be warped unless the water strikes both faces simultaneously.

Such an arrangement sounds expensive and slow. As to cost of equipment, it's not high — perhaps $75 to $150. In operation, the short quench time means surprisingly high outputs per unit, and multiple units may be worked out for lower labor cost. Furthermore, the over-all cost of parts may be amazingly reduced. Consider how you make a washer that you know will warp in hardening: You use extra thick stock, then grind off the warpage at high cost; a lot of the pieces will be scrapped because of excessive warpage or because they are spoiled in grinding. With die quenching, stock 0.010-in. over finished thickness can be used, warpage will be low and uniform, and grinding cost low. Further, if the washer is casehardened, you may by die quenching avoid the cost of putting on a heavy case so there will be some left after it is ground flat.

Another point: The effectiveness of the quenching medium in die quenching is so good that oil may often be used for hardening steels that would require a water quench in an open tank. This reduces the hazard of cracking. If the piece is under ¼ in. thick — and of course if it's made of alloy steel — try oil first. Also try higher oil pressures, up to 80 psi.

The simplest case, that of thin, flat pieces like washers, has been described in some detail, but extension to such things as angle pieces, Belleville springs, even curved parts, is obvious. Just make the dies of appropriate shape, although you will probably find that the die shape must be a little bit different from the desired finished shape because of spring-back. In these special shapes, sometimes it is necessary to plug up a few quenching holes here and there, but results will indicate the proper procedure. This remark

also serves as a reminder that the dies may be so made as to avoid quenching, or give a less powerful quench to, a certain part of the piece such as a thin edge.

Working backward from this really satisfactory way of doing the job, a couple of alternate, possibly-good-enough methods of handling thin, flat pieces may be mentioned:

Pieces may be heated in a box furnace or similar furnace, brought out and pressed quickly between dies to remove any warpage already present, then quenched; this may be moderately successful because the warpage resulting from any internal stress, or from uneven heating, is removed, and because the press will usually crack off the scale so that the subsequent free quench is more effective than otherwise. Sometimes thin pieces can be cooled fast enough to give required hardening if they are cooled between flat steel plates or water-cooled dies. Light armor plate has been so hardened.

The operator of the small heat treating department should certainly get acquainted with the advantages and possibilities of die quenching. A few experiments may prove very worth while.

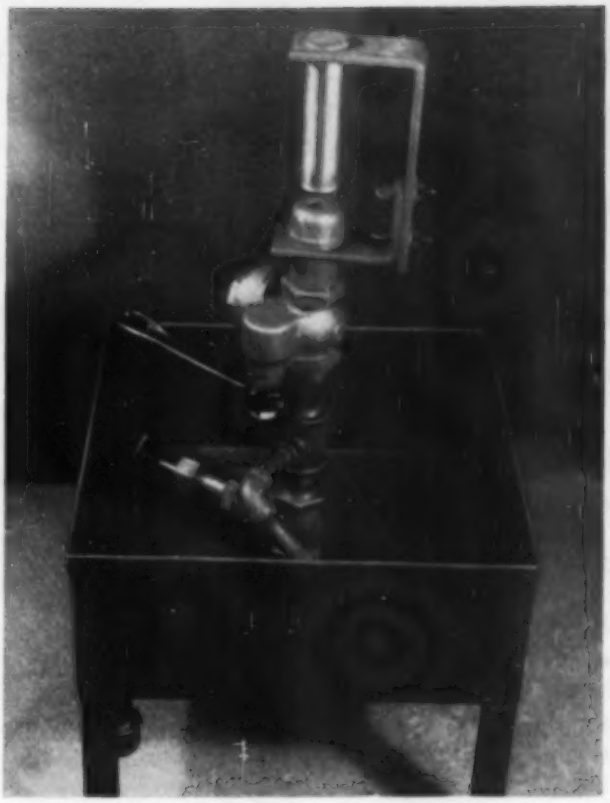
METALLURGICUS

Portable Quenching Fixture for Jominy Hardenability Test

THIS portable quenching fixture weighs only 15½ lb. and has an overall height of 21 in. It operates directly on regular line pressure independent of any other special equipment such as tanks or pumps. It is easy to carry wherever it is needed to check production furnaces and induction heating units. It is constructed from standard fittings and valves, the test holder is of band iron, and the spacer collar of steel tubing.

The photograph of the fixture shows the general construction which consists mainly of an adjusting valve with ¼-in. by-pass opening, a quick action valve, a ¾-in. pipe cap in which a ½-in. round hole is drilled for the quenching jet, and an adjustable specimen holder. A suitable water pan with a ½-in. drain pipe and plug is also provided.

The apparatus is connected directly by hose to a water line and operates on line pressure. Its successful operation depends solely upon the ¼-in. by-pass opening, located between the valve which adjusts the height of the jet and the quick action valve. The by-pass compensates for any irregularities in the line pressure as well as prevents any pressure from building up and



spurting out a higher column of quenching water at the start of the test.

The actual quenching procedure is the same as any other method. After the fixture has been connected to the water line the height of the quenching water column is adjusted to 2½ in. by means of the bottom valve. With water shut off the heated sample is placed in the test holder and the quick opening valve flipped open, whereupon the sample is end quenched by a uniform water column with no surge in the water pressure.

The principal advantages of the fixture are its simple construction and portability, and that it is operated directly on regular water line pressure. (SHERMAN R. LYLE, Metallurgical Dept., Timken Roller Bearing Co.)

Spot Test for Low Chromium

A SPOT PLATE test for chromium in steel, down to 0.10%, was outlined in *Metal Progress* for December 1942 (page 1035), and we have increased the sensitivity to 0.02% by test paper. McKinnon Industries Ltd. of St. Catharines, Ontario, tests all incoming steel scrap destined for malleable iron manufacture. The spot test does the job in less than 5 min.; laboratory analysis may later check the preliminaries. However, once the tester becomes adept he can

judge results from 0.01 to 0.10% chromium to within 2 points.

It is necessary to run a blank for reagents. Solution No. 5 should be mixed fresh every day, as it develops color on standing. As the original article pointed out, standardization of procedure is also of utmost importance.

Solutions Required — No. 1. Water 400 ml., NaOH 20 g., bromine 2.5 ml. (Caution: Handle bromine solution under a hood and wear rubber gloves when mixing.)

No. 2. Water 250 ml., conc. HNO_3 200 ml., 85% phosphoric acid 50 ml.

No. 3. Water 25 ml., conc. H_2SO_4 5 ml.

No. 4. Carbolic acid crystals 5 g., acetic acid 50 ml.

No. 5. S-diphenyl carbazide 100 g., acetic acid 5 ml., ethyl alcohol 50 ml.

Procedure — 1. Clean surface spot of steel by filing or grinding.

2. Place a drop of dissolving acid (Solution No. 2) on cleaned steel and allow to stand for 30 sec. (Time is important.)

3. Touch the flat end of a stirring rod to the steel and place drop on heavy filter paper or spot test paper, where there is already a drop of Solution No. 1.

4. Move rod thoroughly until the brown is evenly distributed.

5. Add one drop of Solution No. 3 and move rod around spot until brown solution dissolves.

6. Add one drop of No. 4, stir slightly.

7. Add one drop of No. 5.

8. A faint pink or violet color of increasing intensity indicates low chromium. 0.10 to 0.20% and higher often give black spots with deep violet rings. These can be checked against results for steels of known anaysis. (REG. H. WILLIAMS, Chief Chemist, McKinnon Industries Ltd.)

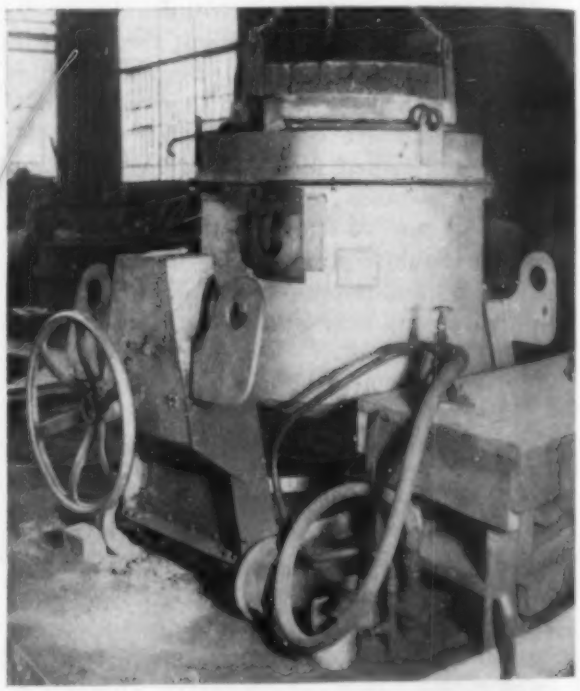
Combination Furnace and Ladle for Aluminum Alloy Foundry

THE accompanying view shows a very successful portable piece of equipment in the form of a 1000-lb. melting furnace, car-trunnion mounted, which is normally hoisted entire by an overhead crane and used as a pouring ladle for large castings. This does away with the bother of preheating transfer ladles or pouring crucibles. As the casting for which the furnace is used has walls about ½ in. thick, the best pouring temperature for the 5% silicon alloy is from 1300 to 1315° F. Ordinarily it would be necessary to heat the aluminum charge to as much as 1475° F. but with the portable furnace-ladle combination it is only necessary to go up to 1380°, thus saving heat and a certain amount of loss by oxidation.

The furnace is lined with fire brick, and has needed only two relinings in handling more than 2500 charges. A graphite crucible would have had to be replaced much more often.

The combination is a conversion of an old oil-fired furnace. It is trunnion-mounted, with two-eyed plates welded on both of the frame uprights for lifting the entire assembly by a four-hook crane sling. Indicating pyrometer is protected within the tilting gear housing.

The furnace is fired by a removable burner, shown on the bench at front. It is easily attached to the sidewall by sliding it into a semi-circular flange and locking it down with a wing nut. The burner fits so that the flame is spiralled downward into the charge. Oil is fed through a flexible metal hose, and air through a rubber hose.



Close-Up of the Portable Unit, Idle, Showing the Removable Burner and Its Leads in the Foreground, and the Flange on the Furnace Sidewall for Mounting Burner. Pouring spout is on opposite side.

The portable furnace and ladle combination, loaded with its charge, weighs about three tons. It can be rolled to any part of the foundry, and picked up bodily, carriage and all, taken to the floor mold and poured. Back on the floor, the cover can be raised and the furnace recharged and burner attached. If necessary the entire shell can be lifted out of its trunnions. (H. J. HUNT, Foreman, Aluminum Melting Shop, General Electric Co.)

Notes on the Properties of Carbon Steels Used in Pipe Manufactured for Elevated Temperature Service

By E. C. Wright
Assistant to President, National Tube Co., Pittsburgh

THE USE of various kinds of pipe at elevated temperatures in chemical plants, oil refineries, and power generating service has given rise to considerable discussion during the past few years regarding the blue heat brittleness, temper brittleness, and strain aging characteristics of the different types of steel which are used for the manufacture of pipe. There are many classes of pipe which are made from several grades of carbon steel. These are tabulated below:

Class of Pipe	Grade of Steel
Bessemer furnace weld pipe	Capped* or rimmed bessemer steel
Openhearth furnace weld pipe	Capped or rimmed openhearth steel
Lap weld pipe	Capped or rimmed openhearth or bessemer steel
Electric weld pipe	Rimmed, semi-killed, or fully killed openhearth steel
Seamless pipe	Semi-killed or fully killed openhearth steel — fully killed bessemer steel

The phenomenon of the aging of steel has been subject to extensive investigation during the past ten years. Numerous allusions have been made as to the effect of nitrogen, phosphorus, oxygen and carbon in promoting aging effects. The terminology is considerably confused, as such terms as "strain aging", "carbon aging", "temper brittleness", "blue heat brittleness", are often used interchangeably to describe similar effects. In view of the fact that pipe has to stand operations for long periods of time in temperature regions between 400 and 1100° F., it seemed pertinent to investigate the various kinds of steel used for the manufacture of pipe to determine the response to blue heat embrittlement or strain aging.

The blue heat characteristics of a steel are often determined by measuring the tensile strength at various temperatures in the blue heat range — ordinarily considered to be between 300 and 600° F. Specimens of standard pipe steels used for making the various kinds of pipe were therefore selected for short-time tests in this range of temperatures. The types of steel tested were:

1. Capped or rimmed bessemer steel.
2. Capped or rimmed openhearth steel.
3. Silicon killed, coarse-grained openhearth steel.
4. Silicon-aluminum killed, fine-grained openhearth steel.
5. Silicon-aluminum killed bessemer steel.

Sections from commercial heats of these grades were rolled to 1-in. diameter bars, normalized at a temperature of 1650° F. prior to machining for tensile test bars. Duplicate tensile tests were made on these grades of steel at room temperature and at 400, 500 and 600° F.; results are shown in Fig. 1 overleaf.

All of the steels of the capped or rimmed type, not "deoxidized" in the ladle, and the coarse-grained, silicon killed openhearth steel, show a very high increase in tensile strength at 400° F., as indicated by the heavy lines in Fig. 1. All of the heats "deoxidized" thoroughly in the ladle, with additions of aluminum and silicon, show practically no increase in tensile strength or only

*"Capped steel" is cast in a "bottle" top mold, and the top metal is caused to solidify rapidly by covering it with a cap which fits neatly into the bottle neck of the mold. The cap stops all rimming action by trapping the gases, but the internal pressure thus set up in the interior of the ingot apparently results in a surface approaching that of rimmed steel. — "The Making, Shaping and Treating of Steel", by J. M. Camp and C. B. Francis, 5th edition (Carnegie-Illinois Steel Corp.)

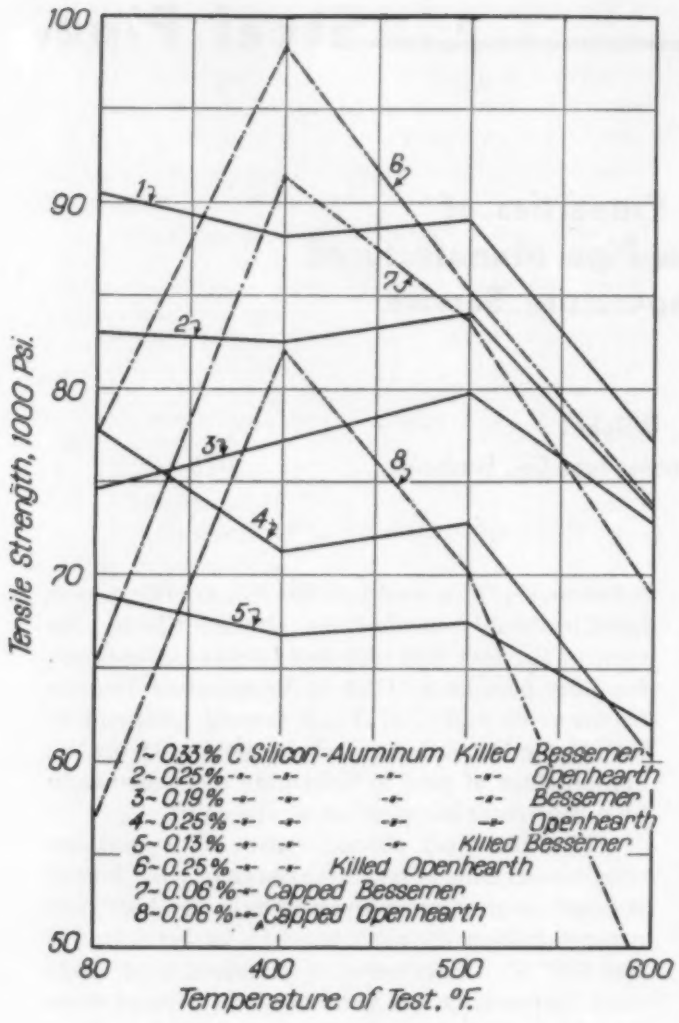


Fig. 1 — Pipe Steels Show no Increase in Tensile Strength in "Blue Heat" Range if at Least 1.5 Lb. Aluminum per Ton Is Added in the Ladle. Speed of testing machine head was constant at 0.2 in. per min.

a slight rise at 500 °F., as indicated by the lighter lines in Fig. 1. (The term "'deoxidation" is put in quotation marks since the effect of the aluminum may be a precipitation or fixing of oxygen or nitrogen in the steel.)

The significant feature of the tensile test results is that only those steels treated with appreciable amounts of aluminum in the ladle, at least 1½ lb. per ton of ingots or more, are free from blue heat brittleness (or, more specifically, increase in tensile strength when tested at 400° F.). This is more clearly brought out in the adjoining tabulation, showing the carbon, manganese, phosphorus and nitrogen content, ladle additions and percentage increase in tensile strength over the room temperature tensile strength.

The direct correlation between the amount of aluminum added and the amount of blue heat brittleness developed is evident in both openhearth and bessemer steels. All of the openhearth steels included in this investigation contained less than 0.0035% nitrogen and less than 0.03% phosphorus, while all of the bessemer steels tested contained approximately 0.013% nitrogen and over 0.065% phosphorus. This series of results, plainly shown in the contrast between heavy and broken lines in Fig. 1, indicated that the thoroughness of "deoxidation" is the predominating factor in influencing blue heat brittleness and that as the oxygen content of the steel is reduced to a low limit, with proper aluminum treatment, the influence of steel making process or of phosphorus or nitrogen, even in combination, becomes negligible.

This conclusion checks experience in recent years with other steel products.

An investigation of the strain aging characteristics of this series of steels was also undertaken by means of the strain sensitivity test developed by the Jones and Laughlin Steel Corp. and described in detail in previous publications, particularly in *Metal Progress* for November 1937, page 669, and in *Proceedings* of the American Society for Testing Materials, vol. 39, page 571. This test was found to be a very delicate indicator of strain sensitivity, both in the "as strained" state and also after specimens were strained and aged between 400 and 550° F. Time of aging did not seem to be important at the higher temperatures.

Ladle Additions to the Heats Tested

Type of Steel	Analysis				Ladle Addition Lb. Per Ton	Change in Ultimate on Heating to 400° F.
	C	P	Mn	N		
Openhearth	0.06	0.020	0.40	0.003	0.4 Al	+ 45%
	0.26	0.018	0.88	0.0026	9.4 FeSi; 0.5 Al	+ 27%
	0.23	0.018	0.74	0.003	6.4 FeSi; 0.9 Al	+ 17%
	0.25	0.024	0.99	0.003	12.0 FeSi; 1.2 Al	+ 1%*
	0.24	0.026	0.90	0.0032	6.6 FeSi; 1.6 Al	− 8%*
	0.34	0.024	0.65	0.003	4.9 FeSi; 2.0 Al	− 7%*
Bessemer	0.07	0.094	0.29	0.016	None	+ 40%
	0.16	0.080	0.51	0.014	10.0 FeSi; 1.2 Al	+ 23%
	0.18	0.081	0.49	0.015	10.0 FeSi; 2.2 Al	+ 6%*
	0.32	0.072	0.91	0.014	8.8 FeSi; 2.2 Al	− 2%*
	0.13	0.074	0.45	0.016	9.3 FeSi; 3.8 Al	+ 1%

*From results at 500° F.

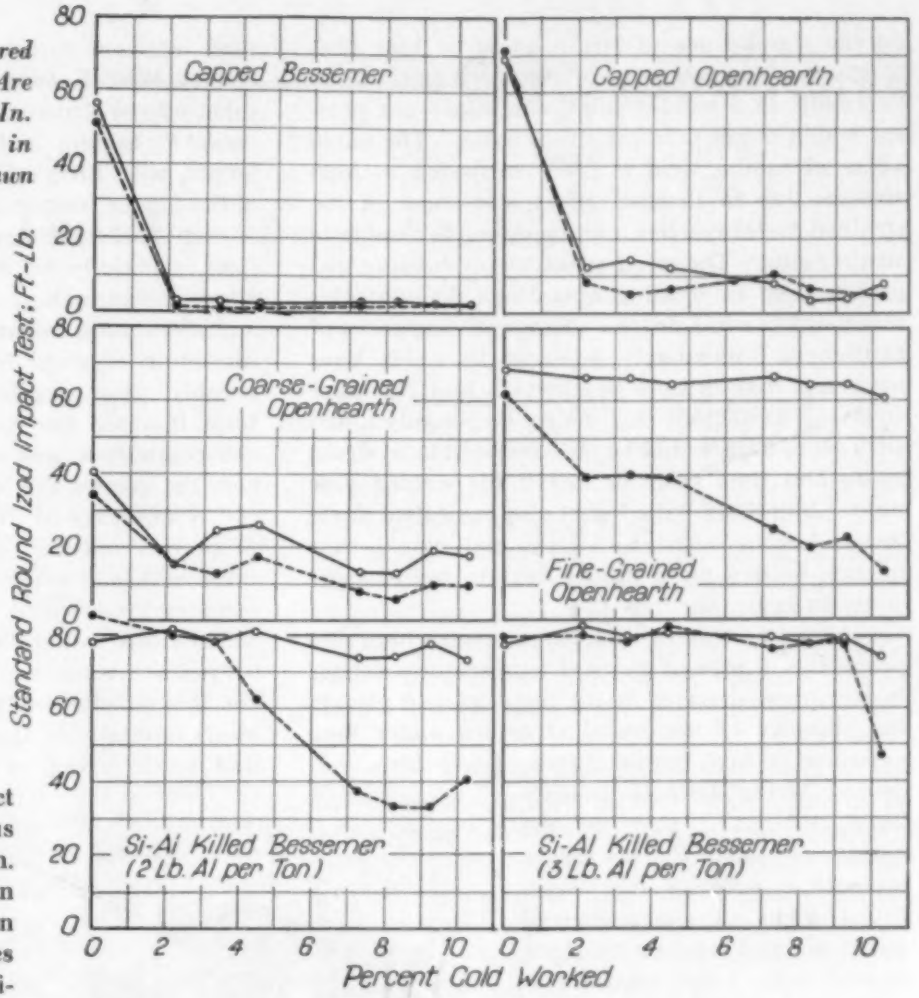


Fig. 2— Round Bars, Tapered From 0.475 to 0.450 In. Are Drawn Through a 0.450-In. Die, V-Notched, and Broken in Izod Machine, Either as Drawn (Solid Lines) or After Aging at 550° F. (Broken Lines). Results of this "strain sensitivity test" agree with the indications of tests in Fig. 1

The main feature of the strain sensitivity test consists of cold drawing a bar, previously machined on a taper, in order to obtain a reduction of area along the bar-length varying from 0 to 10%. The bars, after cold forming, and after cold forming and aging, are then notched with the Izod V-notch and broken to determine how the impact properties vary with various amounts of cold deformation. The results of these strain sensitivity tests are shown in Fig. 2 for the same classes of steel which were previously subjected to short-time high-temperature tests in the blue heat temperature region.

It will be noted that the responses to strain aging correspond quite definitely with the increase in blue heat brittleness previously reported. The capped bessemer steel, the capped openhearth steel and the silicon killed, coarse-grained openhearth steel all show a high susceptibility to strain aging and loss in impact toughness, both after straining and after straining and aging. On the other hand, the openhearth and bessemer steels killed in the ladle with silicon-aluminum (more than 1½ lb. of aluminum per ton) show a considerable resistance to strain aging and maintain a high degree of toughness, not only after straining alone but also after straining and aging in the region of 400 to 550° F.

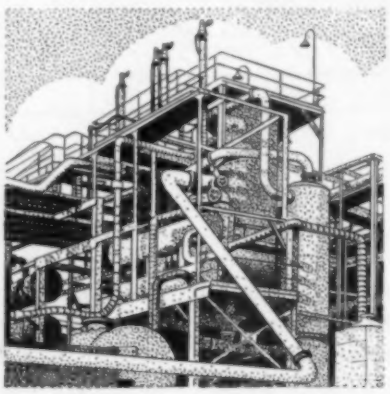
The curves in Fig. 2 all represent aging at 550° F. but similar results were obtained on aging at temperatures between 400 and 550° F. It is evident that bessemer steels thoroughly killed with silicon and aluminum, free from susceptibility to strain aging, may be readily produced. Five years of experience with killed bessemer steel for seamless pipe has proved this on hundreds of heats.

The lap weld openhearth and bessemer steel pipe, and the furnace weld openhearth and bessemer steel pipe have been used satisfactorily for elevated temperature service for over 40 years. Lately, as temperatures and pressures have increased, the tendency has been to use seamless pipe or electric resistance welded pipe for the more severe conditions. These two grades of pipe may be made from semi-killed, coarse-grained steels, or from fine-grained steels, deoxidized with a considerable amount of silicon and aluminum or with aluminum alone. In either case, large quantities of pipe have been produced which may or may not be highly susceptible to strain aging or blue heat hardness. Such pipe has been used satisfactorily at elevated temperatures for many years in the form of seamless pipe and for the past five years as electric welded pipe. It seems apparent from this experience that whether pipe is free from strain aging or blue heat brittleness has not been an important factor in the use of pipe in high temperature service.

The recent increase in the use of welding for the assembly of pipe lines in units operating at high temperatures may have an important bearing

on the significance of strain aging or blue heat brittleness characteristics of the pipe steels used. Certainly, in a welded joint, conditions are present which might produce strain aging. The metal adjacent to the weld is often subjected to high stresses due to thermal effect and some of the strained metal reaches a temperature favorable to strain aging. The great value of pre-heating and post-heating in welding operations demonstrates this point in some degree. Numerous instances of brittleness immediately adjacent to welds have been reported in both openhearth and bessemer steels. It is obvious that a steel thoroughly killed with aluminum would be less susceptible to strain aging and thus safer to install for welded pipe lines. Aluminum killed steel also exhibits a much lower Jominy hardenability, and would thus quench harden more mildly next to welds, especially in heavy sections.

Another item of discussion concerning the properties of pipe at elevated temperatures relates to the creep strength of the material and also to the stability of the metal structure under long exposure to high temperatures. Creep tests conducted during the past 10 years have indicated that, in the region of 1000° F., the creep strength is superior for silicon killed steels of coarse-grained structure, and inferior on steels treated with large amounts of aluminum to produce a fine-grained structure. The creep strength of rimmed steels is usually reported to be lower than fine-grained steels killed with silicon-aluminum. The meager published information indicates that the fine-grained steels killed with silicon-aluminum have better creep resistance up to 850° F. than the rimmed steels or coarse-grained, silicon killed steels. The fine-grained bessemer steels, killed with silicon-aluminum, have better creep resistance than the same type made in openhearths, when tested at both 850 and 1000° F. This is believed to be due to the higher phosphorus content of the acid bessemer steels.



There has also been some evidence that carbides in the steel transform directly to graphite and that the rate of this transformation may be influenced by deoxidation practices. Evidences of graphite formation in carbon steels at temperatures as low as 850° F. have been reported, and frequent occurrences of graphite accompanying the spheroidization of carbon steel have been noted in service around 1000 to 1200° F. Carbon steels exposed to temperatures in the region of 1100 to 1200° F. for long periods tend to develop spheroidized structures and, after longer exposure, massive carbides in the grain boundaries of the ferrite, with little evidence of graphite formation at the higher temperatures. The actual grain size of the steel specimens, the composition of the steel, especially in reference to the amount of alloy contamination and percentages of silicon and aluminum, apparently may all influence the formation of graphite, either favorably or unfavorably. It is reported that high aluminum additions increase the rate of graphitization and of spheroidization, and also that the higher the carbon, the greater the tendency to graphitize.

A summary of the known facts regarding the properties and uses of pipe at elevated temperatures makes it evident that the fine-grained silicon-aluminum killed steels or straight aluminum killed steels would be superior in all respects for service at temperatures up to 850° F. The reason for this conclusion is that pipe made from such steels is relatively free from blue heat brittleness and strain aging, is more suitable for welding without complicated pre-heating and post-heating requirements, has greater resistance to creep below 850° F., possesses a fine-grained structure with superior toughness, has better impact properties at both elevated and sub-zero temperatures, and is probably free from graphite formation or deterioration at service temperatures.

The use of carbon steel pipe at temperatures above 850° F. presents a complicated problem. The A.S.M.E. Boiler Code specifies allowable stress values for several types of carbon steel pipe at temperatures up to 1000° F. In this temperature range, the coarse-grained, silicon killed steels would undoubtedly have superior creep strength and possibly less tendency to graphite formation. On the other hand, in the fabrication of such coarse-grained steels the effects of decreased ductility and toughness, high blue heat brittleness, and sensitivity to strain aging would have to be carefully considered, as these properties would have to be sacrificed in order to obtain the higher creep strength which would probably be most desirable at the higher temperature range. The best possible solution to this difficulty would doubtless be to limit the use of plain carbon steel pipe to the maximum temperature of 850° F. and use some of the simple alloy steels at higher temperatures.

Correspondence

Letters from Home and Abroad

Origin of Steel Cartridges

LONG ISLAND CITY, N. Y.

To the Readers of METAL PROGRESS:

On page 49 of the January 1943 issue, Col. Turner states (in his interesting article on "Steel Cartridge Cases for Artillery Ammunition"): "One small company in the United States made a very few steel cartridge cases in the early days of World War I but, unfortunately, this company ceased to exist many years ago and much of the record of its work was lost."

I presume that the author referred to the experiments carried on by the U. S. Cartridge Co. in 1914 and 1915. However, long before that, another firm, the Union Metallic Cartridge Co. (well known to Americans of that day as the makers of U.M.C. ammunition) made a considerable quantity of shot-gun shells in 10, 12, 16, and 20 gage out of steel by both hot and cold drawing.

Back in 1906 many men still used metallic (brass) shells in their shot-guns, as smokeless powders had not been fully developed nor popularized to the degree that they are today. I believe that it was in the early part of 1906 that this company made these shells, of the gages mentioned, for experimental purposes. I still have one or two of the 20-gage shells in my collection.

Low carbon steels can be drawn into cartridge cases almost as readily as they have been drawn from cartridge brass, and by the cold process. The brass (or all-metal) shell was the logical one to use with black powder, as the propellant is entirely burned before the charge is driven out of the shell. Old-timers will remember the suspicion they had for the shells that later came along, with a short brass cup combined with a long paper sleeve. The paper sleeve came into its own with the perfection of smokeless powder. In reality, the paper shell reduced the muzzle velocity of the shot, because the crimp took some power to iron it out.

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Consulting Engineer, Forged Carbides, Inc.
(Arms and Ammunition Editor,
Hunting & Fishing in Canada)

Danger of Rapid Local Failures From High Creep Rates

SHEFFIELD, ENGLAND

To the Readers of METAL PROGRESS:

It is of course well known that at ordinary temperatures the steels used in engineering construction are reasonably ductile materials which will stretch considerably under tensile stress before they break; fracture, when it finally occurs, travels across the distorted grains and not along their boundaries.

At high temperatures, however, steels do not always behave in this fashion. They often do so if tension is applied in such a way as to stretch the hot steel rapidly, but if the rate of extension is slow, fracture is generally intercrystalline, there is little or no deformation of the grains themselves and total elongation before fracture is small.

This characteristic difference in the behavior of steel under tension at high and low temperatures was probably first noted by Rosenhain and Humphrey, who also put forward the idea of an "equicohesive temperature" (see "The Tenacity, Deformation and Fracture of Soft Steel at High Temperatures" in the *Journal* of the Iron & Steel Institute, 1913-I, page 219). Below this equicohesive temperature the crystalline grains are regarded as being weaker than the grain boundary material, whilst above it the grains are the stronger. The greater rate at which the strength of the grain boundary material decreased with rise of temperature was attributed to its amorphous structure, which caused it to have properties of the same type as those of glass or an undercooled liquid.

The same conception also provides an explanation for the differing effects, at high temperatures, of stresses producing rapid and slow extensions. Although modern ideas may replace the term "amorphous" with one indicative of imperfect crystallisation, the conception is still useful in visualising the effects of stress at high temperatures.

The fact that intercrystalline fracture is

characteristic of many, if not all, steels when they are slowly stretched at high temperatures has since been noted by many investigators. Thus French and his colleagues at the National Bureau of Standards showed, in Research Paper 192 (July 1930), that intercrystalline fracture could occur in austenitic chromium-nickel steels at temperatures at least as low as 1000° F.

In his book on "Stainless Iron and Steel" (1931 edition, page 443) the present writer quoted an example of an austenitic 16-10 chromium-nickel steel which failed in this way with very little elongation after being held for three weeks under a stress of only 4500 psi. at 700° C. (1290° F.); fracture was possibly aggravated in this case by the precipitation of a network of carbide at the grain boundaries.

Data since obtained — for example in "Some Aspects of the Behavior of Carbon and Molybdenum Steels at High Temperatures", by Jenkins, Tapsell, Mellor and Johnson, *Transactions* of the Chemical Engineering Congress in London, 1936, Vol. I, page 122 — have shown that both ordinary carbon and low alloy steels fracture in the same way when stretched slowly at temperatures of the order of 550° C. (1000° F.). In all such cases, intercrystalline failure occurs before the test piece has stretched to any great extent; frequently the amount is well under 1%.

Some particularly interesting results were recently obtained by Avery, Cook and Fellowes in tests on austenitic chromium-nickel steels of the 25-12 type. These were published in Technical Paper No. 1480, A.I.M.E., and showed that incipient intercrystalline failure was already evident in samples stressed for approximately 1000 hr. at temperatures of 1400° F. or thereabouts, under loads which produced considerably less than 1% extension during the testing period. In some cases the test piece did not actually break under load but subsequent examination showed that intercrystalline rupture had already developed to an unmistakable extent.

The fact that incipient intercrystalline failure can and does occur before the steel has stretched even 1% raises important questions in connection with the design of high pressure, high temperature plant.

Thus, at ordinary temperatures, local concentrations of stress due to grooves and other causes are often safely dissipated by slight local yielding; in high temperature plant, on the other hand, stress concentrations of a similar magnitude will probably result in incipient intercrystalline fracture; hence local stress concentrations must be carefully avoided in such plant.

Secondly, the question of the permissible extension of some part during its working life assumes a new aspect. Many times, permanence of dimensions of plant within narrow limits is essential for successful operation, but in other places questions of design may indicate that an extension of 1 or 2% or even more, during the working life of a particular part, would not have serious effects on its performance and thus lead to the use of higher design stresses such as would produce extensions of this order during the expected working life.

If, however, these stress conditions result in intercrystalline rupture developing along favorably oriented grain boundaries before the part has extended even 0.5%, it is obvious that serious failure may result in a much shorter period than the expected working life.

One may well question, therefore, the advisability of adopting creep rates as high as 10^{-6} per hr. (1% extension in 10,000 hr., which is rather less than 14 months) when determining "limiting creep stress" values, unless it is understood that design stresses should be limited to a small fraction of these "limiting creep stress" values, or that the life of parts to which they are to be applied is not expected to be more than a few months. Doubtless these values may appear more impressive to the uninitiated than the markedly lower values corresponding to safer rates of creep (for example, 10^{-7} per hr.), but is this of any great importance?

J. H. G. MONYPENNY
Metallurgist, Brown, Bayley's Steel Works, Ltd.

Allotropic Relations for a Group of Elements Near Iron

JOHANNESBURG, TRANSVAAL

To the Readers of METAL PROGRESS:

The metallurgist of a philosophic turn of mind is fascinated by the writings of Seitz, Wilson, Hume-Rothery, Shockley, Dushman, and Darrow on the structure of atoms and the nature of the metallic state. If he accepts any physical model of the atom's architecture, he cannot help but speculate on the changes which occur during the allotropic change in certain of the elements. As a matter of fact the crystal forms which the metals assume still have to be worked into some regular pattern or checker-board, analogous to the Periodic Sequence of such importance to chemical theory. Hence I venture to submit what may be a little orderly light on that maze of experimental fact.

A group of elements displaying a peculiar wealth of allotropic modifications is found near

to and includes the element iron. Thus we have:

Cr (atomic number 24)

α Cr ; b. c. cu.
β Cr (?) ; co. cu.
γ Cr ; hex.*

Mn (atomic number 25)

α Mn ; co. cu.
β Mn ; co. cu.
γ Mn ; f. c. tet.*
the axial ratio c/a = 0.934.

Fe (atomic number 26)

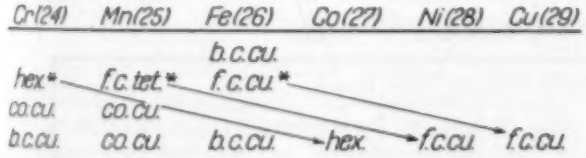
α Fe ; b. c. cu.
γ Fe ; f. c. cu.*
δ Fe ; b. c. cu.

ABBREVIATIONS: b. c. cu. = body centered cubic; co. cu. = a complicated cubic form; hex. = hexagonal close packing; f. c. tet. = face centered cubic; (tetragonal). For *, see text.

Cobalt (27) also shows polymorphism, but does not obey the relationship to be explained.

The phases in the above tabulation marked by an asterisk, all existing at elevated temperatures, represent forms of a greater compactness than the forms existing at lower temperatures, for each particular element. They are, in fact, packings of spheres in chromium and iron, and for manganese very nearly so. In these "compact" forms each element has succeeded in simplifying its original crystallographic design.

Three elements of a basically simple design are now found further on in the Periodic Table in cobalt, nickel and copper, and one might look for a relationship between the above-named elements and these. Let us therefore cast a glance at the following table:



A relationship of the type mentioned is clearly indicated by the three arrows. It maintains that the "compact" modifications of Cr, Mn, Fe imitate the basal forms of the respective elements whose atomic number is higher by 3 units (Co, Ni, Cu).

The relation is of particular interest in the case of iron. The free iron atom has the following electronic arrangement:

SHELL:	K	L	M	N (45)
ELECTRONS:	2	2, 6	2, 6, 6	2

Copper on the other hand has similarly:

SHELL:	K	L	M	N (45)
ELECTRONS:	2	2, 6	2, 6, 10	1

The space lattice of α Fe, however, would seem to have an electronic density of something like 0.2 electron per atom for the 45-"band". (F. Seitz; "The Modern Theory of Solids", 1940, p. 430.) For the copper lattice it may be assumed that the band arrangement is one closely akin to the given shell distribution, because the M-shell is completely occupied. Assuming that there is some validity to the relation expressed above for the six adjoining elements, I would conclude that γ Fe also approaches the pattern of one electron per atom for the 45-band. The transition from α to γ Fe would therefore appear to mean a transfer of electronic charge from the M-zone to the 45-band, representing an increase in ionization.

There are indications that such transfer of electronic charge begins below A_3, the allotropic change point, but the bulk effect is expected to occur only at that temperature. It appears that R. Smoluchowski (*Metal Progress*, March 1942, p. 363), via a different route, found similarly that "an increase in the number of electrons per iron atom increases the stability of the γ phase and decreases the stability of the α phase."

For Co and Ni (solid state) the electron density in the 45-band is given as 0.7 and 0.6 electron per atom respectively by Seitz, loc. cit. (See also A. H. Wilson "Semi-Conductors and Metals", 1939, p. 29, for information about nickel.) The relation put forth in these lines leads one to expect similar states of density (45-band) for γ Cr and γ Mn, as well.

O. A. TESCHE
Metallurgical Physicist
Steel Laboratory, State Mines

Hardenability of a Heat Measured From Cast Test Pieces

CANTON, OHIO

To the Readers of METAL PROGRESS:

This discussion of cast hardenability testing was inspired by a statement in Critical Points in the January 1943 issue of *Metal Progress*, page 61. The statement attributed to Don Norquist of Sheffield Steel Corp. was that "cast test pieces give erratic hardenability tests". One would infer from the subsequent text that hardenability results calculated by Grossmann's method are superior to cast tests when correlated with results from forged specimens, even though the direct statements refer only to S.A.E. 4150 steel for armor piercing shot. If the statement referred to is given a more general interpretation to include all steels, it is at variance with the experience of a number of steel companies. The following information is offered in support of cast end-quench hardenability testing, since it serves a very useful purpose as a rapid, inexpensive

method of obtaining this essential information, early in the history of a heat.

It is of paramount importance that the mold for the test piece be designed to produce the proper amount of chill in order that the austenitic grain size of the casting at the moment of quenching be comparable to the forged and prior normalized specimen under the same conditions. Experience has shown that this can best be accomplished with a ratio of metal in mold to metal in casting of from 7:1 to 10:1. All steels obviously do not produce identical hardenability values from cast and forged tests, due principally to this grain size factor, but the difference between the two remains essentially constant for a given steel.

The test piece may be cast integral with the collar, in which case it is only necessary to remove the shrinkhead and cut to length before testing. An alternate method is to cast a test piece of the collar diameter and machine to size, necessitating a tempering treatment for many steels. Tempering the cast test at 1200° F. does not appreciably affect the results. All normal testing precautions must be rigidly adhered to.

The accompanying table lists typical end-quench results for a number of heats, showing the relationship existing between the cast and the forged and normalized specimens taken from the same portion of the heat. A definite relationship is found to exist even though the results are not identical. Experience has shown, however, that the difference, when it does occur, is quite constant and can be allowed for with confidence in interpreting the cast results. The fairly rare occurrence of wide divergence between cast and forged specimens, as illustrated by the third 4150 heat listed, is so far inexplicable, but is not as frequent an occurrence as the equally inexplicable differences between calculated and actual hardenability values.

Cast hardenability testing has been in constant use as a production control for a period of over two years in the plants of several steel companies, including that of the writer's, during which time literally thousands of such determinations have been made. It has been found to be at least as accurate as any other method of rapidly determining the hardenability of a heat, and has the further advantage of automatically averaging the variable of segregation which sometimes affects the forged test. To those who do not like to rely upon calculated hardenability values alone, it represents a method of satisfactory accuracy and of sufficient rapidity to permit of a determination to be made while the ingots are in the soaking pits. The saving in time, equipment and labor in these days of universal shortages of these items cannot be overlooked.

E. S. Rowland
Research Metallurgist,
Timken Roller Bearing Co.

(For The Steel Standardization Group; a committee of staff metallurgists of Bethlehem, Carnegie-Illinois, Great Lakes, Pittsburgh Crucible, Republic and Timken companies, chairmanned by F. E. McCleary, metallurgical engineer of Chrysler Corp.)

End-Quench Hardenability Tests, Rockwell "C" Scale

Type Steel	Type Test	Inches From End of Test Bar													
		1/16	1/18	¼	⅜	½	⅝	¾	⅞	1	1⅛	1¼	1½	1¾	2
4150	Cast	62	61	61	60	60	60	59	59	58	58	58	57	55	52
	Forged	*61*	*61*	*61*	*60*	*59*	*59*	*59*	*59*	*59*	*57*	*57*	*55*	*53*	*52*
4150	Cast	62	62	62	62	62	61	61	60	60	59	59	59	59	58
	Forged	*63*	*63*	*62*	*62*	*61*	*61*	*61*	*60*	*60*	*60*	*60*	*60*	*59*	*59*
4150	Cast	60	60	60	60	60	59	58	57	55	54	52	47	45	44
	Forged	*59*	*60*	*59*	*58*	*57*	*57*	*56*	*52*	*51*	*51*	*46*	*41*	*36*	*33*
4340	Cast	55	55	54	54	54	54	53	52	52	52	52	52	52	51
	Forged	*54*	*54*	*54*	*53*	*53*	*53*	*53*	*52*	*52*	*51*	*52*	*52*	*52*	*51*
4340	Cast	54	55	55	54	54	53	53	53	53	53	53	52	52	53
	Forged	*55*	*55*	*55*	*54*	*54*	*54*	*53*	*53*	*53*	*53*	*53*	*53*	*53*	*53*
4330	Cast	52	52	52	53	52	52	51	50	49	47	45	43	40	39
	Forged	*53*	*54*	*53*	*53*	*53*	*52*	*51*	*49*	*48*	*47*	*45*	*43*	*42*	*40*
8749	Cast	59	59	58	56	52	45	41	37	34	33	32	30	29	28
	Forged	*59*	*59*	*58*	*56*	*53*	*50*	*46*	*42*	*38*	*35*	*34*	*31*	*30*	*30*
52100	Cast	65	65	61	45	42	38	36	35	33	32	32	31	30	30
	Forged	*66*	*66*	*64*	*47*	*43*	*40*	*37*	*36*	*35*	*33*	*32*	*31*	*30*	*30*
52100	Cast	66	66	63	48	41	41	42	39	37	35	33	31	29	29
	Forged	*66*	*66*	*64*	*52*	*42*	*42*	*42*	*39*	*37*	*36*	*34*	*32*	*30*	*30*
52100	Cast	65	65	61	45	41	41	37	35	34	33	32	31	30	29
	Forged	*66*	*66*	*63*	*48*	*43*	*43*	*39*	*37*	*36*	*35*	*34*	*32*	*30*	*29*

Information supplied by an Industrial Publication

Not only the quality of steel castings, but their practicability and production cost under ordinary foundry conditions are influenced by design. The following suggestions are offered as an aid to proper design.

1. Whenever possible, all sections should be designed for uniform thickness.

2. Structural design involving abrupt changes in section should be avoided.

3. Sharp corners at adjoining sections should be eliminated whenever possible.

4. When the structure becomes very complicated, it is better to break it into several components that can be cast separately and assembled by welding or bolting.

5. In designing unfed sections in "L" or "V" shapes, it is suggested that all sharp corners at the junction be replaced by radii so that this section becomes slightly smaller than that of the arms.

6. In designing sections that join to make an "X", it is suggested that two of the arms be offset considerably.

7. In the case of unfed "T" and "X" sections, the radii at the junctions should be relatively small.

Personals

JESTYN WILLIAMS, formerly with Mills Novelty Co., is now chief metallurgist for Brad Foote Gear Works, Inc., Cicero, Ill.

CHARLES E. STEVENS, JR., formerly heat treat supervisor and salvage engineer, Ranger Aircraft Engines, Farmingdale, N. Y., is now chief engineer, B. F. Hirsch, Inc., New York City.

BYRON A. WILSON, Government inspection coordinator, of the Copperweld Steel Co., Warren, Ohio, has been appointed assistant inspector of naval materials, U. S. Navy Dept., Cleveland District.

ARTHUR B. WESTERMAN, formerly associated with the Metals Research Laboratory of Carnegie Institute of Technology, has been appointed to the research staff of Battelle Memorial Institute in the division of physical metallurgy.

SAM TOUR has resigned as civilian director of the Frankford Arsenal Laboratory Division to devote more time to the recently organized Sam Tour & Co., Inc. and other activities. CECIL C. FAWCETT has been appointed associate director of the Laboratory Division of Frankford Arsenal.

THOMAS M. BOYD, formerly laboratory assistant at the Chrysler plant in New Castle, Ind., is now a chemist in the Chevrolet Division of General Motors Corp. at Muncie, Ind.

BEN J. GOODMAN, sales engineer, now represents prominent tool firms in upper New York State, with headquarters at Rochester, N. Y.

R. J. SHIBLES has left the Glenn L. Martin-Nebraska Co. to go in the service as lieutenant (j.g.), U.S.N.R., stationed at the Naval Air Station, Quonset Point, R. I.

ROBERT ONAN has been appointed sales representative in the Chicago area for the Duraloy Co. of Scottdale, Pa.

Appointed by Peter A. Frasse and Co., Inc.: RUSSELL B. BARNETT, formerly Philadelphia district manager, to vice-president in charge of company sales in New York; VAL HANSEL, formerly assistant manager of the New York sales department, to manager; JOHN D. DRUMMOND, formerly assistant manager in Philadelphia, to manager; LESLIE N. STETSON, manager of the Buffalo district.

Recent graduates added to the staff of the Division of Physical Metallurgy of the Naval Research Laboratory at Anacostia, D. C.: JACK H. GOODYEAR and WILLIAM JOHNSON, Lafayette College; RUSSELL G. HARDY, Carnegie Institute of Technology; NICHOLAS KOWALCUK, University of Alabama; ENSIGN FRANK S. MCKENNA, Lehigh University; ENSIGN DONALD B. ROACH, University of Illinois; ENSIGN JOHN ROBERTSON, Northeastern University; GEOFFREY J. SIEGEL, Rensselaer Polytechnic Institute; SIDNEY SIEGEL, Massachusetts Institute of Technology; LT. J. G. FREDERICK R. STECKEL, Case School of Applied Science; ENSIGN ROBERT C. WAYNE, Columbia University.

There's a Christmas rush on telephone wires, too

Help keep war-crowded circuits clear on December 24, 25 and 26.

Please use Long Distance only if it is vital.

War needs the wires—even on holidays.

BELL TELEPHONE SYSTEM

Personals

CHARLES H. JUNGE, previously research metallurgist at National Malleable and Steel Castings Co., Cleveland, is now metallurgist with Armour Research Foundation, Chicago.

JOSEPH ROCK, JR. is now with the tooling research and special assignment section at Boeing Fortress Plant, Seattle.

CHARLES F. SECK has accepted a position with Russell Electric Co., as factory managing engineer in charge of plant and manufacturing engineering.

KENNETH B. YOUNGDAHL has been made president of Supercut, Inc., New York City.

HOWARD A. SMITH has joined the technical staff of Beech Aircraft Corp., Wichita, Kansas, as metallurgical engineer to aid in process control and development work.

M. D. JOHNSON, chief inspector, Caterpillar Tractor Co., Peoria, Ill., has been made chairman of the Committee on Inspection of Castings for the American Foundrymen's Association.

W. E. COOPER, chief metallurgist of the Fairey Aviation Co., Ltd., Beaconsfield, England, has been made chairman of the War Materials Committee of the British Aircraft Industry.

Officers elected at the annual meeting of the stockholders of Vanadium-Alloys Steel Co., Latrobe, Pa.: ROY C. MCKENNA, chairman of the board; FLOYD ROSE, president; JAMES P. GILL, vice-president; F. P. UNDERWOOD, secretary and C. R. GETTEMY, assistant secretary.

WESLEY HASKINS HAMMOND has been re-assigned from Pearl Harbor, where he was chief chemist, Industrial Department, U. S. Navy Yard, to the U. S. Naval Drydocks in San Francisco, where he is senior materials engineer in the planning section.

R. R. CAMPBELL is leaving his position as chief metallurgist with McKinnon Industries Limited of St. Catharines, Ont., to be associated with Centrifugal Casting Co., Muskegon, Mich.

ROBERT RYAN, formerly metallurgist with National Smelting Co., is now foundry metallurgist for Bohn Aluminum & Brass Corp., Plant No. 24 in Adrian, Mich.

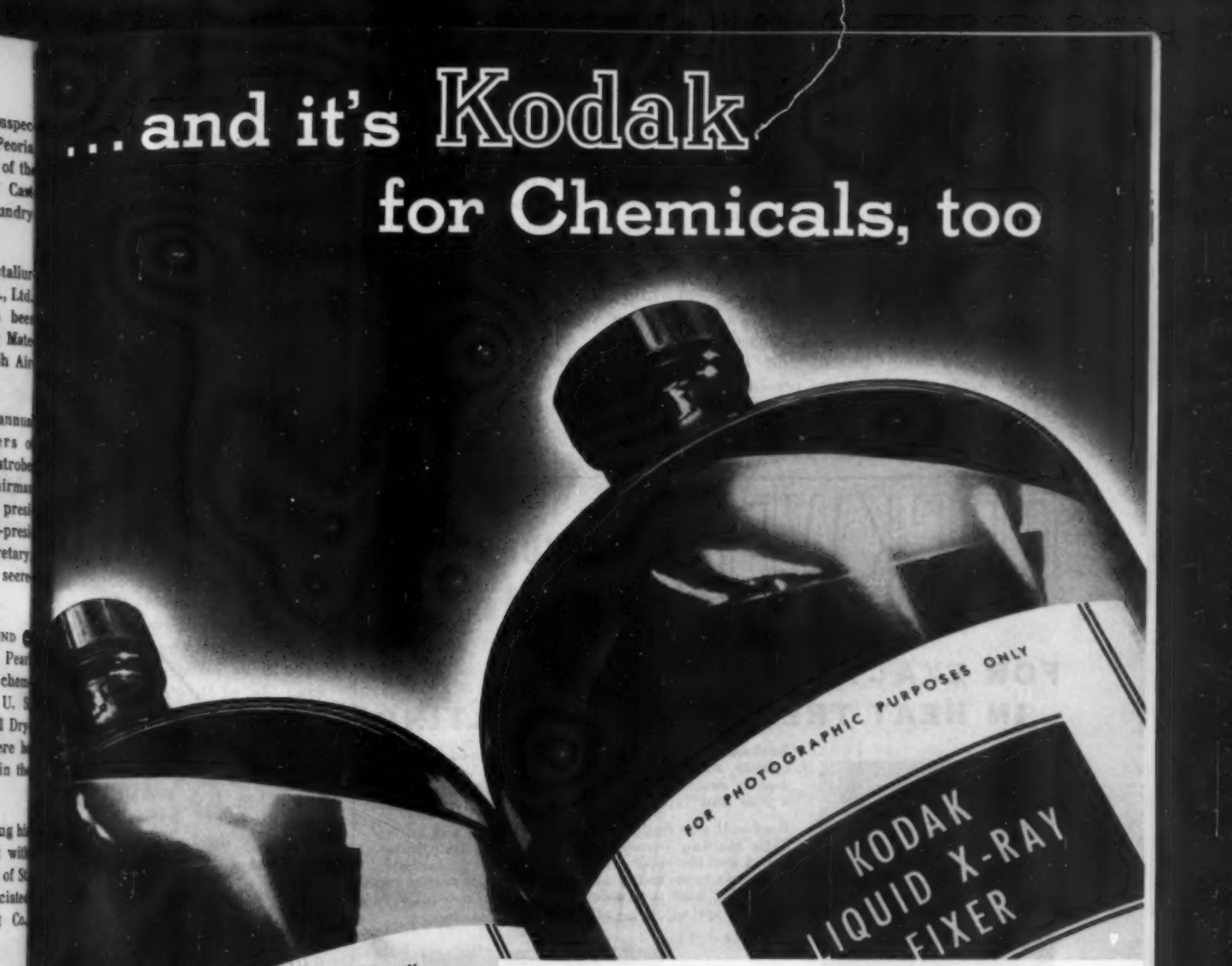
PAT MALI, formerly assistant superintendent at the Burke Steel Co., Rochester, N. Y., is now superintendent for the Vulcan Steam Forge Co., Buffalo, N. Y.

EUGENE M. STEIN, formerly metallurgist with Deere and Co., Moline, Ill., is now associated with Gunite Foundries Corp., Rockford, Ill.

C. C. ASHLEY, formerly liaison engineer in war construction program for Shell Oil Co., has been transferred to the Shell Chemical Division as chief engineer of the Cactus Ordnance Works.

ANDREW T. KORNYLAK is now with James Allen Tuck & Associates, New York City.

...and it's Kodak for Chemicals, too



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Personals

WILLIAM G. SCHNEIDER is now employed as product development engineer, Nordberg Mfg. Co., Milwaukee.

FRED L. WOLF has resigned as deputy director of the Mica-Graphite Division, Minerals Bureau, War Production Board, and has been made executive vice-president of the Ross-Tacony Crucible Co., Philadelphia.

Appointed to a newly created Technical Advisory Committee to the Conversion Engineering Section of the New York Ordnance District: GREGORY J. COMSTOCK, professor of powder metallurgy, Stevens Institute of Technology; AUGUSTUS B. KINZEL, Union Carbide & Carbon Corp.; THOMAS H. WICKENDEN, manager of the Development and Research Division, The International Nickel Co., Inc.; RALPH L. EVANS, Ralph L. Evans Associates; HOWARD A. POILLON, president, Research Corp.

VICTOR F. J. TLACH has resigned as president of Darwin & Milner, Inc., Cleveland, and has joined the American Agile Corp., Cleveland, specialists in welding electrodes.

Appointed to the engineering staff of Park Chemical Co., Detroit: RICHARD HAMMERSTEIN and T. CLARK, as service engineers in the heat treating division.

CHARLES F. KETTERING, vice-president, General Motors Corp., Detroit, has been named chairman of a new advisory committee on the development of the Technological Institute of Northwestern University, Evanston, Ill.

D. T. WELLMAN, formerly in the sales department of the Dow Chemical Co. at Midland, Mich., will head the new branch office recently established in Cleveland. He will be assisted by T. H. CALDWELL, JR. of Dow's magnesium production division.

RALPH R. CASPER has accepted a temporary position with the Bliss Forge Co., Inc., Buffalo, N. Y., as superintendent, until he is called for active duty with the Army Air Corps as an aviation cadet.

THOMAS L. MOORE, formerly west coast representative for the Steel Division of War Production Board, has resigned to resume his duties with Rustless Iron and Steel Corp. as district manager on the Pacific Coast.

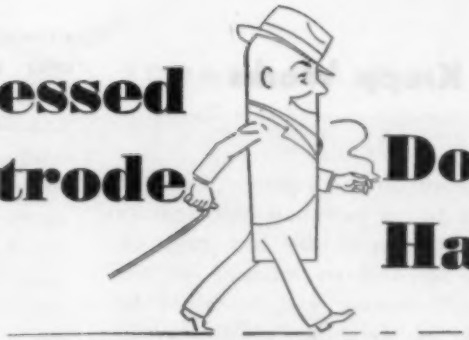
W. FRIEDRICH is now associated with Wicks Carbide & Alloy in Long Island City, N. Y., as metallurgical engineer in charge of production.

THOMAS A. WRIGHT has been elected president and ROBERT BELL, vice-president and research director of Lucius Pitkin, Inc., metallurgical chemists and engineers, in New York City.

ALVIN G. COOK, formerly of the Dunkirk, N. Y. plant of the Allegheny Ludlum Steel Corp., now metallurgist for Forging and Casting Corp., Ferndale, Mich.

CHARLES G. PURNELL, formerly contact metallurgist, is special representative, heat treating for Carnegie-Illinois Steel Corp., Pittsburgh.

A Well-Dressed Electrode Does a Handsome Job!



If you're using resistance welding to speed production, insist on correct electrode dressing technique in your plant. With proper dressing of electrodes between production runs, you help assure—

1. Sounder, Cleaner Welds—because the shape and size of any resistance welding electrode must be kept uniform to maintain proper current density in the weld. Choosing the right contour of electrode for a given job . . . and then maintaining the welding face by correct dressing . . . is as important as the choice of the welding current.

2. Longer Life for Electrodes—because incorrect dressing methods often remove too much of the electrode surface. Using a coarse file to dress spot welding tips, for instance, is wasteful. By machining tips on any small lathe equipped with a suitable collet or chuck, you can keep the amount of electrode material removed down to about .025" per dressing! Or you can use the Mallory Tip Dresser, a hand tool that does a quick machining job . . . with no need for removing tips from their water-cooled holders.

To assure longer electrode life, keep electrode surfaces clean. Use a fine abrasive cloth and a light, even pressure. It's better *not* to use an ordinary shop file, especially one that may be contaminated with iron filings, since iron particles imbedded in a copper-alloy welding electrode will tend to "burn" and pit the electrode —and the work.

TECHNICAL INFORMATION, FREE! Correct dressing technique is just one of the factors involved in getting more output and better welds from your resistance welding electrodes. Mallory metallurgists and welding engineers have taken the lead for many years in developing superior electrode materials, designs and cooling methods. They can help you to select spot welding tips, seam welding rolls, and dies for flash or butt or projection welding . . . so that you can be sure of faster production and sounder welds . . . Write us for specific information . . . If you don't have a copy, ask for the valuable 79-page MALLORY RESISTANCE WELDING DATA BOOK. It's yours for the asking!

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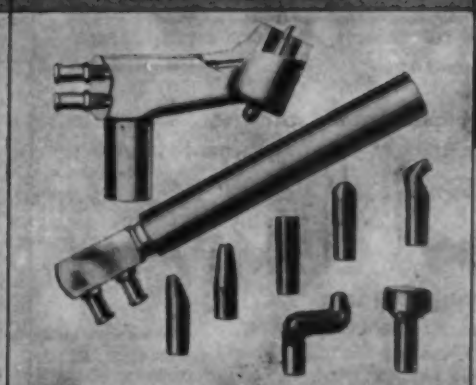
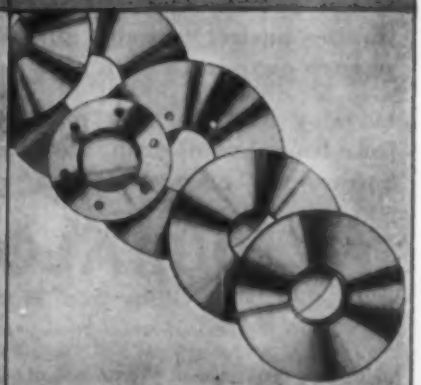
		

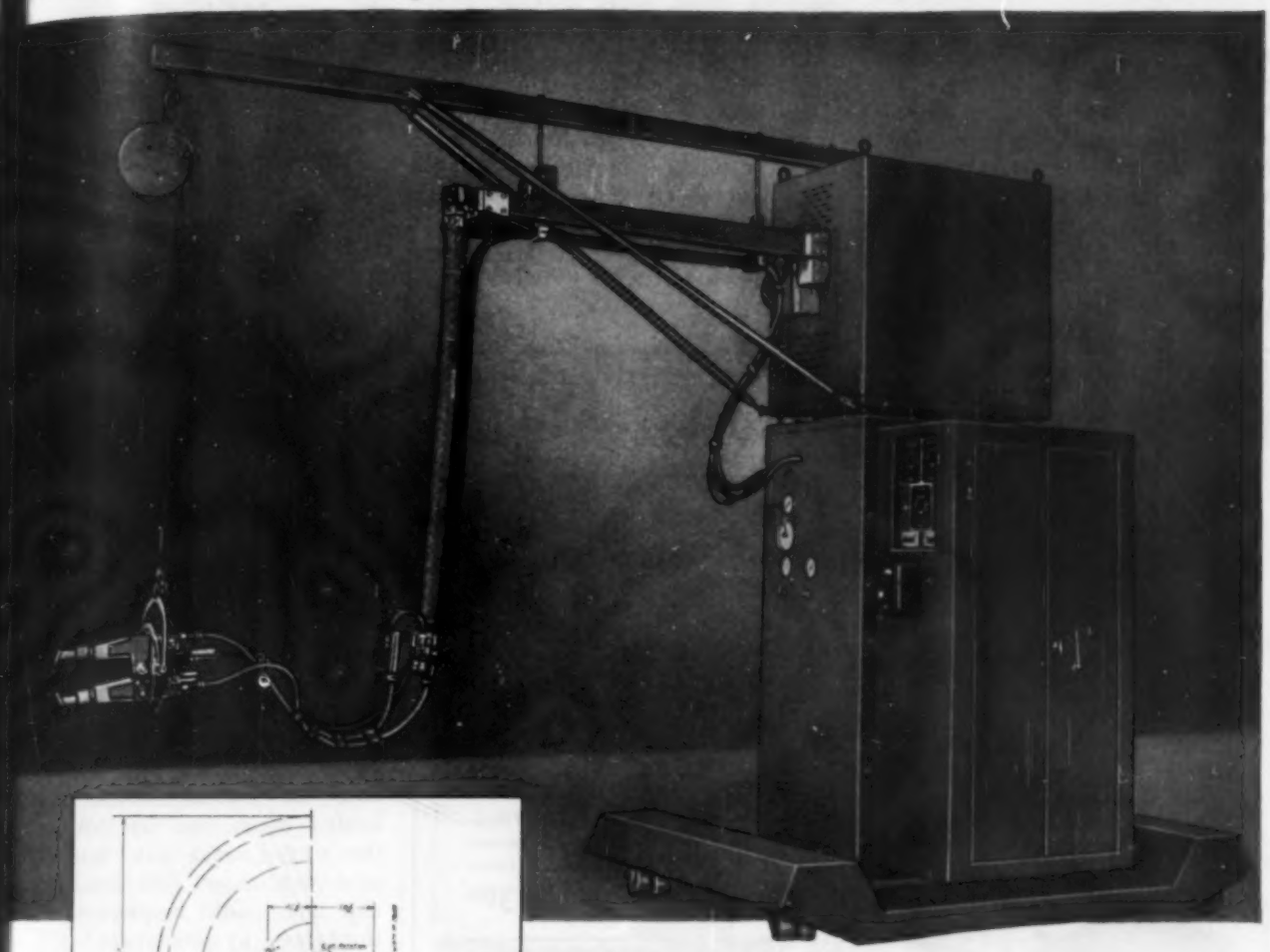
SPEEDIER PRODUCTION · LESS DOWN TIME · BETTER WELDING · LOWER COST

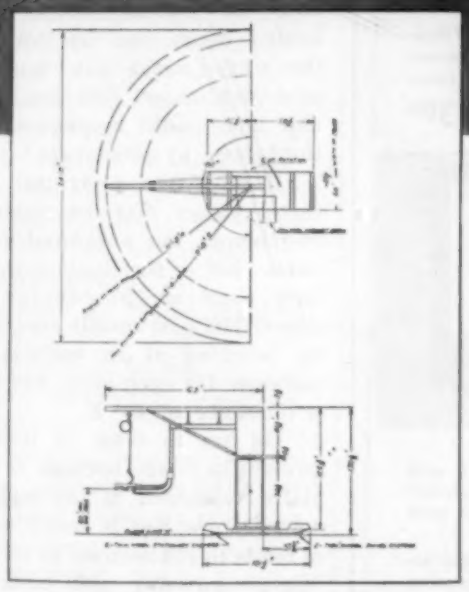
Bomb Damage to the Krupp Works

DAMAGE by air raids to Krupp's armament and engineering works concentrated at Essen is assessed by *The Engineer*, Oct. 29, 1943, page 339, in an article entitled "Air Force Targets". A detailed map of the steel foundries, machine shops and locomotive works shows 185 buildings important enough to be listed on the legend. Each of these has a hatching showing its condition after the last raid on July 26, and an estimate of the overall damage can therefore be made by weighting a "destroyed" building as 4, "badly damaged" as 3 and so on; unharmed buildings rating a zero. Such a computation shows the average damage level over this concentrated region 2 miles long by 1 mile wide to be 2.14—roughly, half destroyed. Such results, attained by reconnaissance photographs, warrant *The Engineer's* conservative statement that "productional activity at these huge works, employing from 160,000 to 200,000 persons, is at a very low ebb. This is confirmed by reports of neutral observers, who speak of shortage of plates for submarine hulls in Hamburg, and lack of forgings and other Krupp parts in a Berlin engine works." In the six raids 117 aircraft were lost. It has been officially stated that "over the last few months the actual loss of machines has not exceeded 5% of those employed", but in attacking such a well defended target as Essen the proportionate losses must have been considerably greater than the average. In return, the article points out that the damage on these raids is far more widespread than to Krupp's fabrication departments alone, extending north to the blast furnace and steel plants, and includes the railway stations, the non-ferrous smelters of T. H. Goldschmidt A.G., and a great number of surrounding habitations.

Of course it might very well be (although it is not likely) that the really important shops in a half-destroyed area would not be so badly hit as some less essential auxiliaries. In view of possible regrouping of shops since the war started and since bombing started, it is impossible to say with accuracy the exact purpose for which each building appearing on an air-view is being employed. However one acre of pattern shop has been destroyed, a machine shop covering 3.5 acres and making field gun carriages, and three other similar but smaller shops as well. Three out of four of the buildings devoted to heat treatment have been totally destroyed. The Diesel engine works (3 acres) has been totally destroyed. In the shell forging and turning sections three large buildings were extensively damaged by direct hits with high-explosive bombs, while incendiaries caused widespread damage in that region.

HELPING TO SOLVE TODAY'S WARTIME PRODUCTION PROBLEMS





Dimension drawing of Sciaky Type PS2R-1, 100 KW, Radial Portable Spot Welder, showing maximum reach of gun and 180° rotation. Capacity: Aluminum and light alloys in two thicknesses of .016" minimum up to and including .064"—corrosion resisting steels up to two thicknesses of .080".

it reaches your welding problems

This radial portable spot welder for aluminum and light alloys will fill a long felt need in the fabrication of light structures. Sciaky engineering now makes it possible to bring the advantages of aluminum spot welding *to the assembly*. Crowded and fixed jigs can be easily reached. Tacking operations as well as structural welding can be accomplished with greater speed and efficiency.

Stored Energy with Preheating and Variable Pressure, features which are established as superior in the welding of aluminum, are employed. The control cabinet, main welding reactor, monorail and special copper bars connecting the gun to cables are all built as a self contained unit. This unit is mounted on a stationary column and pivots on a vertical axis by means of ball bearings mounted inside the column. Transversal movement of the gun on a straight line can be 12 feet in length. The gun may also be moved vertically 20 inches above and below a minimum position.

SCIAKY BROS.

Manufacturers of a Complete Line of
A.C. and D.C. Electric Resistance Welding Machines
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Railway Bearing Metals

(Continued from page 1120)

which act as test pads of white metal. These are then sheared from the bronze by static loading in a compression testing machine. Although it is preferable, at present, to apply metal to a machined surface of the bronze shell, it is nevertheless possible to obtain reasonably good results on metal in the cast condition.

Reclamation of Scrap — Tests indicate that the metal melted out from old bearings, together with melting dross, clean borings, and mixed borings of bronze and white metal from the machine shops, concentrated for renovation, may be used and reclaimed repeatedly without any deterioration of the running properties of white metal. To obtain improved methods for dealing with mixed borings and residues, some studies were commenced in 1937 which ultimately led to the development of the so-called Bradley process, to be described below.

The possibility of powdering the more fusible white metal and screening it from the bronze appeared attractive. Preliminary experiments showed that it was possible to powder the white metals while hot, without affecting the bronze. A rotating drum furnace was therefore designed with forced air circulation and automatic temperature control. A steel drum, 15 in. diameter by 42 in. long, rotates inside the furnace setting. The drum has two fins, 3 in. deep, diametrically opposed and extending along its whole length. The furnace is electrically heated and its temperature is controlled to within ±5° F. A drum speed of 20 r.p.m. was found satisfactory, and experiments were conducted on charges weighing up to 40 lb. These were sealed in the drum and after heating to the set temperature were tumbled for about 10 min. and then withdrawn without further cooling. The internal fins served to lift and drop the charge onto the interior surface of the heated drum, and by this means the white metal was reduced by heat and impact to a fine powder and later could be removed from the bronze by screening.

It would appear that white-metal alloys may be powdered throughout the solidus-liquidus range, but at the liquidus temperature itself no powdering takes place. The best results are obtained by working at an optimum temperature for each alloy, and within a tolerance of 10° F.

Oil up to 0.4% is invariably present in mixed borings. It is partially vaporized at the separation temperature, but in batch working it tends to concentrate on the white metal powder and hinders its agglomeration when being remelted to ingot form. The effect of organic matter on the actual separation itself is uncertain.

When dealing with rich batches (above 50% white metal), it is desirable to add further contaminants in the proportion of 1% of the charge for every 25% white metal to insure that the white metal powder does not sinter or stick together. The sodium carbonate-sodium chloride eutectic (56%

odium carbonate, which melts at 185° F.) is suitable, for it later cts as a flux to free the white etal particles from their oxide oating.

Our recovery plant, converted to ontinuous operation, is now giv- g very satisfactory results and he output is about 200 to 300 lb. er hr. In the continuous furnace, he borings and other metallic lines re delivered from a bin by a screw onveyor to a tubular feeder. This as inclined vanes cast on its inner urface, so as it rotates slowly the ontents are worked toward the far nd where they fall into the large rum of the furnace proper. This s set on a slight incline, and the eparated metals fall out through ots in the far end, down a chute, nto a waiting barrow. Both tubu- r feeder and rotating furnace rum have their own furnace set- ing; temperature in the latter is aintained constant by recirculat- g the atmosphere.

It is doubtful whether the plant ill give a clean separation with harges containing over 70% white etal, unless the through-put is educed. Charges of high white etal content should be considered or liquation treatment, followed by radley treatment of the sintered nd contaminated bronze.

It may not be out of place to mphasize the toxic nature of the owder produced, so that efficient eans are required to make the lant dust-tight.

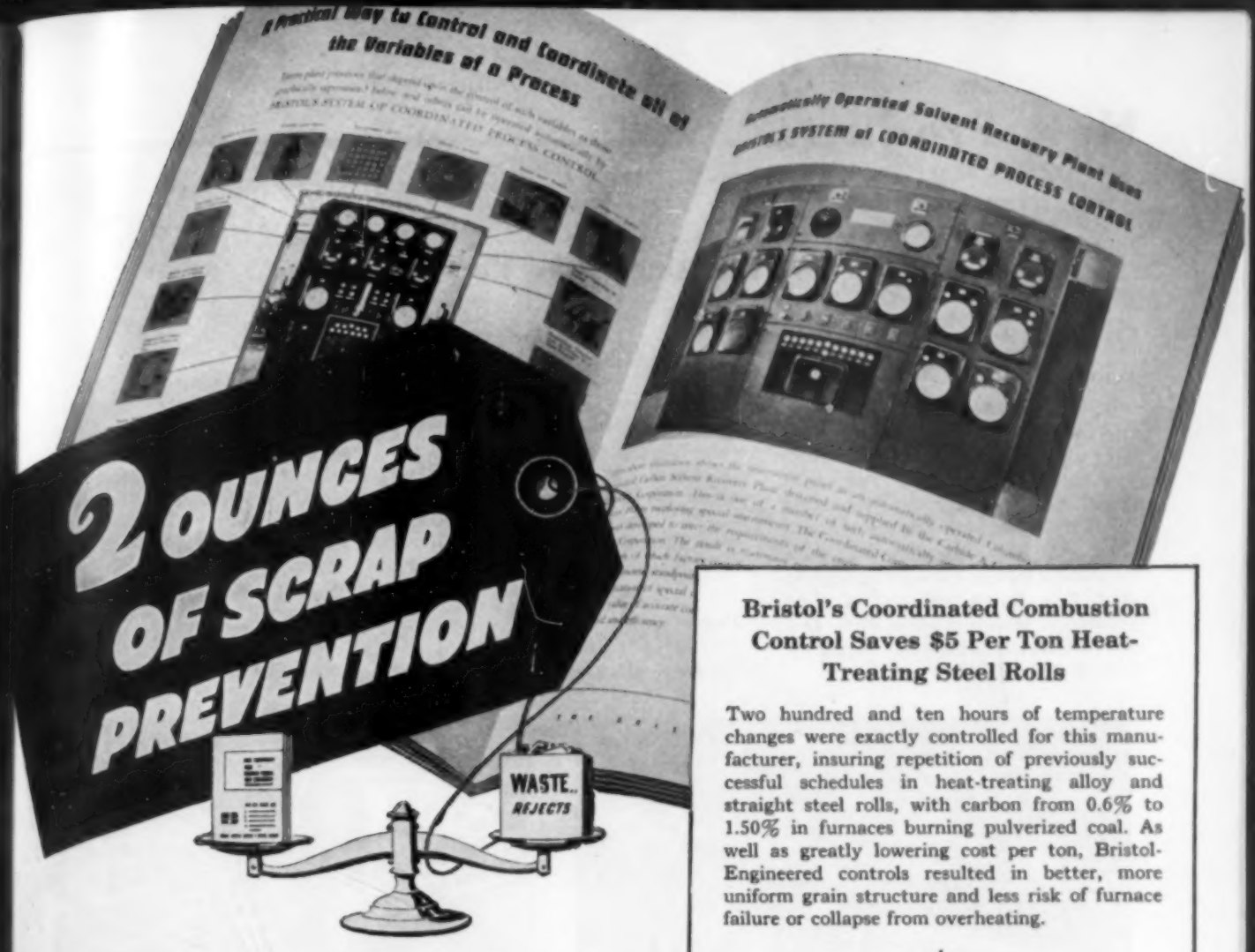
The dividing line for satisfac- ory size may conveniently be of 0 or 40-mesh. Charges of mixed orings coarser than this are suit- ble for treatment.

It is quite feasible to obtain a irly clean separation of any two usible alloys with different freez- g ranges, provided that in the ne with the lower solidus the ptimum separation temperature oes not exceed the solidus of the ther.

Presumably powder is produced y breaking up along a liquid inter- ace, and subsequent surface oxida- on (aided by contaminants) revents reunion. No appreciable segregation of the different white-metal constituents occurs during powdering.

The operating temperature is apparently too low to cause any "tinning" of the bronze particles, and after the removal of the white-metal powder by sieving the fines and the coarse, they may be separately melted and pigged. The reconversion of the whole of the white metal powder to ingot form is difficult if refractory contaminants are present. For complete recovery it is essential to work at temperatures at which the oil has been largely destroyed, about 1500° F. It is impracticable to melt even the clean white metal powder without the use of fluxes, and the salt-sodium carbonate eutectic mixture has proved the most economical and efficient. In good practice each constituent of the charge is cleanly separated, the whole of the bronze is recovered, and at least 97% of the white-metal powder is put into ingot form.


America's New Source of
Aluminum · Ingot · Sheet
Extrusions · Wire · Rod
Bar · Forgings · Tubing
Foil · Powder · · · and
Finished Aircraft Parts



Saving scarce raw materials by eliminating waste and rejects . . . is only one of the many wartime problems being solved today with the help of Bristol's instrument engineering. In many cases, sending for one of Bristol's instrument-data bulletins has been the first step towards substantial savings.

CHECK *YOUR* PROBLEM HERE:

1. Lack of skilled men?
2. Shortage of raw materials?
3. Need to increase output without increasing space or equipment?
4. Unnecessary spoilage and rejects?
5. Errors in putting new products into production?

Write for Bulletin 512 — Facts, Case Studies, Results of Complete Automatic Control of Plant Processes

Here, in one concise bulletin, are the essentials of Bristol's System of Coordinated Process Control, including list of applications and outline of what has already been achieved by many manufacturers in food, textile, metal, plastics, rubber and other process industries. Write for it today, together with any of the other free bulletins described at right, addressing The Bristol Company, 103 Bristol Road, Waterbury, Conn.

BRISTOL ... *Gives YOU the Most from Heat*

AUTOMATIC CONTROLLING AND RECORDING INSTRUMENTS

THE BRISTOL COMPANY, Waterbury, Connecticut

The Bristol Co. of Canada, Ltd.
Toronto, Ontario

Bristol's Instrument Co., Ltd.
London, N. W. 10, England

Bristol's Coordinated Combustion Control Saves $5 Per Ton Heat-Treating Steel Rolls

Two hundred and ten hours of temperature changes were exactly controlled for this manufacturer, insuring repetition of previously successful schedules in heat-treating alloy and straight steel rolls, with carbon from 0.6% to 1.50% in furnaces burning pulverized coal. As well as greatly lowering cost per ton, Bristol-Engineered controls resulted in better, more uniform grain structure and less risk of furnace failure or collapse from overheating.

☆

FREE— These Clear, Concise, Complete Bulletins Sum Up Latest Advances in Instruments for Your Industry

THE BRISTOL COMPANY
103 Bristol Road, Waterbury, Conn.

☐ Please send me free Bulletin 512, together with other bulletins checked here.

☐ Bulletin T302 — Describes Bristol's Full-Compensated, Liquid-Filled Recording Thermometers, desirable for a wide variety of critical temperature-measuring problems; nomenclature, parts, schematic diagrams, and partial list of available charts.

☐ Bulletin 536 — Modern pH instruments for exact measurement and automatic control of hydrogen-ion concentration are here described, together with new glass electrode method.

☐ Bulletin A112 — Bristol's Free Vane Controllers for temperature, flow, liquid level, pressure, draft, humidity, pH value and time program — analyzed and described with special attention to new convertible feature permitting adaptation to changing processes.

NAME.....

COMPANY.....

ADDRESS.....

.....

New Products

Equipment and Processes

Pebble Finish

New "pebble" finish for metal surfaces has been developed by Sherwin-Williams Co., Cleveland, and is promoted as a successful solution to the problem of how to dress-up a machine surface without fillers, sanding and numerous coats of sealing paint. Photograph shows that this finish effectively hides scratches, grinding scars and other surface irregularities shown at the left of the casting.

Carbide Grinder

New floor type carbide grinder (with a heavy base, drum type on-off-reverse switch, heavier tables, and storage compartment for wheels and tools) has been announced by Thomas Prosser & Son, 120 Wall St., New York City. New machine removes metal rapidly when rough grinding, as well as accurately finishing all single-point tools to smooth, keen cutting edges with flat surfaces, held exactly to desired angles. Either silicon carbide or diamond wheels can be used for grinding carbide, or aluminum oxide wheels for grinding stellite or high speed steel. Prompt deliveries.

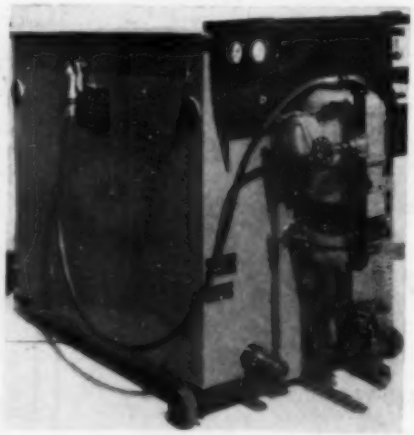
Checking Dial Indicator

New device for checking accuracy of dial indicators is announced by Clark Instrument Inc., 10200 Ford Road, Dearborn, Mich., called the "Clarkator". Indicator to be tested is mounted on top the device with its spindle resting on a lapped angle block, which is advanced or retracted by a micrometer screw. After clamping the indicator in position so that its zero reading coincides with the dial face on the Clarkator, the screw is revolved in either direction to check other indicator readings. Simultaneous readings are by means of mirror combinations.

Degreasers

Complete line of standard and specially designed vapor and solvent degreasers is now offered by the Magnus Chemical Co., Garwood, N. J. Just announced is a new portable multi-purpose washing machine for cleaning a wide range of large and small parts. This new machine is designed to meet the needs of metal fabricators whose production rates do not warrant the installation of large, fully automatic, washing equipment.

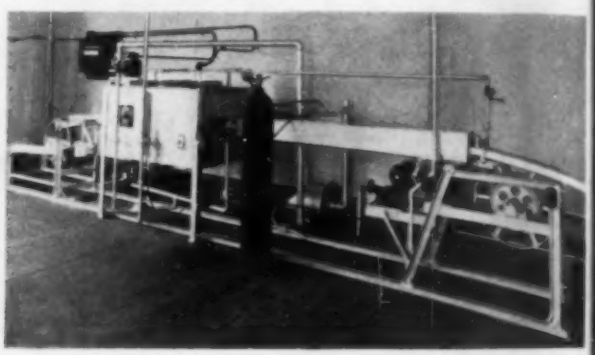
This company has also devel-



oped a new metal coating compound, preparatory to drawing. Material is applied as a dip coating to high or low carbon steel wire, copper coated wire and stainless steel wire after pickling. For further information, write the company, attention Dept. MP.

Brazing, Soldering, Annealing Furnace

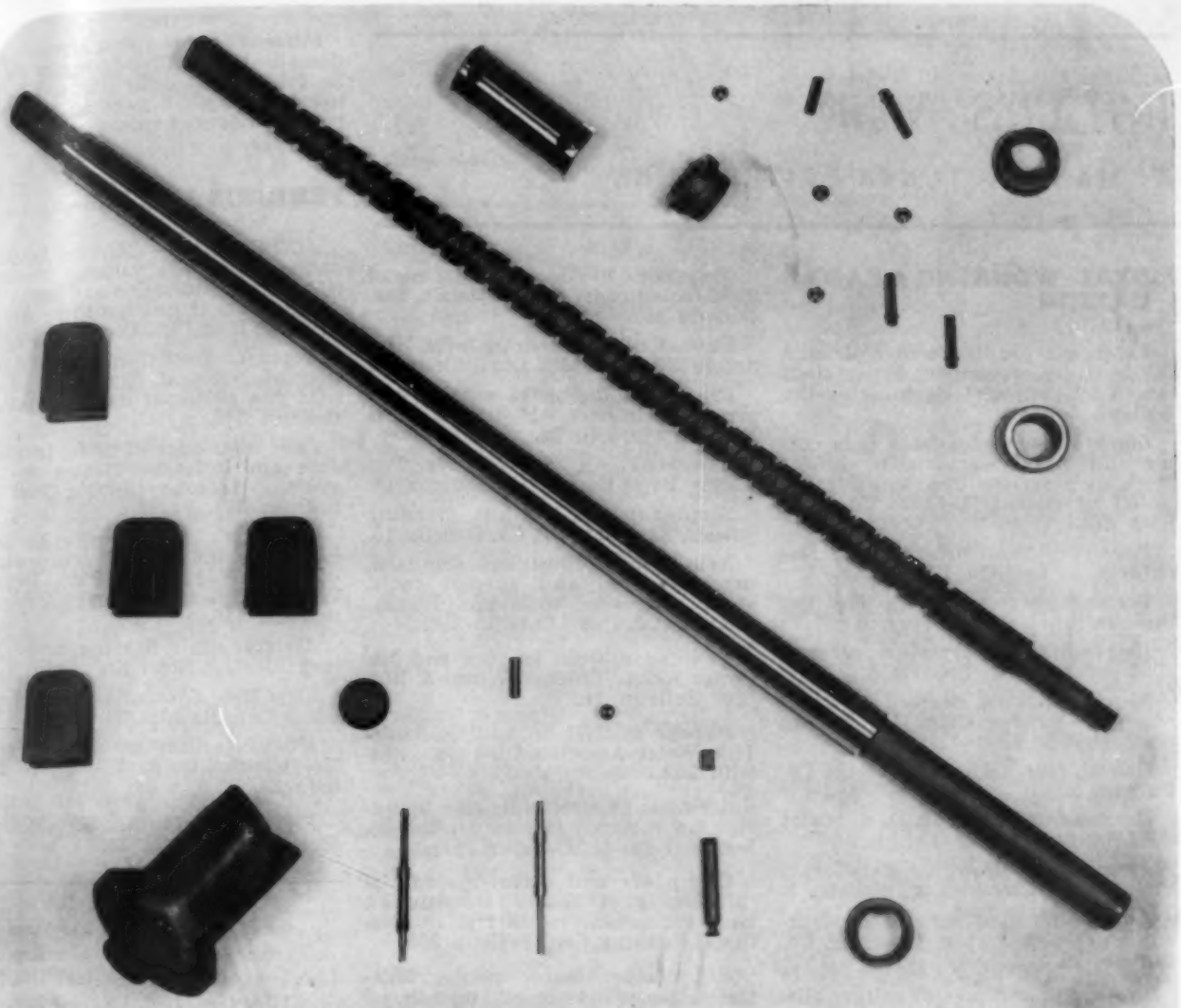
Small furnace for continuous automatic brazing of copper pieces,



for silver soldering, for sintering metal powder compacts or for bright annealing of metal strip that requires a uniformly bright, high surface finish, has been developed by W. S. Rockwell Co., New York 7. Adequate atmospheres eliminate pickling, cleaning and drying. In the past, non-oxidizing furnaces for this kind of work have been electrically heated. However, the design of this unit permits the utilization of gas, with a gas burner firing from each end of the furnace. Electric heating can also be arranged. Complete automatic temperature control is provided.

Radiant Heater and Resistor

Designed for use in annealing ovens, electric furnaces and wherever high temperature radiant heat is required, a new radiant heater and resistor has been developed by Techtmann Industries, Inc., 828 N. Broadway, Milwaukee, Wis. Use is said to have proved that its core will not deteriorate at temperatures up to 1700° F.



Stainless Steel Parts

SURFACE HARDENED BY THE DREVER PROCESS

CASE DEPTHS:

Straight Chromium Grades: .010"
Types 410, 416, 430, etc.

Chromium-Nickel Grades: .005"
Types 302, 303, 316, 347, etc.

Heavier case depths if required.

HOT HARDNESS TEST:

Brinell Hardness No.	70°	1000°
Drever Surface Hardened	1050	710

Write today for Bulletin 21 giving details of the new uses to which you may now put Stainless Steels with Surface Hardening by Drever.

THE DREVER CO.

790 E. VENANGO STREET, PHILADELPHIA 34, PENNSYLVANIA

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

METAL WORKING • FABRICATION

Automatic profilers and hydraulic benders are described in catalogs issued by the Pines Engineering Co. Bulletin 344.

Clark 3-blade adjustable hole cutter and 3-blade adjustable surface facer are described in new illustrated leaflet by Robert H. Clark Co. Bulletin 348.

Powdered metal presses. Kux Machine Co. Bulletin 1.

Forging presses. Ajax Mfg. Co. Bulletin 2.

Horizontal extrusion presses. Hydropress, Inc. Bulletin 3.

36-page pictorial story of the Cecostamp. Cambersburg Engineering Co. Bulletin 4.

Cutting Oils. Cities Service Oil Co. Bulletin 5.

Cutting Oil Handbook. D. A. Stuart Oil Co. Bulletin 6.

Presses for Powder Metallurgy. F. J. Stokes Machine Co. Bulletin 7.

Information and data on straightening press. Anderson Bros. Mfg. Co. Bulletin 10.

Properties and uses of cutting oils. Gulf Oil Corp. Bulletin 8.

Properties, applications and use of hard-facing rods. Coast Metals, Inc. Bulletin 249.

Surface coated abrasive belts. Minnesota Mining & Mfg. Co. Bulletin 12.

Presses for the metal working and process industries. Hydraulic Press Mfg. Co. Bulletin 20.

Handbook on aircraft riveting. Cherry Rivet Company. Bulletin 14.

Savings in oils, tool bits, grinding wheels. Sparkler Mfg. Co. Bulletin 15.

New catalog illustrates standard, non-standard, and special tools, shows prices of tools and blanks. Kennametal, Inc. Bulletin 250.

Mounted wheels, Handee and Hi-Power tools. Chicago Wheel & Mfg. Co. Bulletin 21.

20-page booklet on cutting fluids. Tide Water Associated Oil Co. Bulletin 252.

Air tools in steel mills and foundries are pictured in new booklet by Ingersoll-Rand. Bulletin 255.

Complete and valuable study of "Machining of Metals", including chip formation, is offered by National Refining Co. Bulletin 335.

Big, comprehensive catalog illustrates line of power presses offered by Minster Machine Co. Bulletin 320.

Parsons oval bag dust arrestors are described and 12 advantages listed in folder issued by Parsons Engineering Corp. Important advantage is reclamation of valuable dust. Bulletin 228.

FERROUS METALS

ACIPCO Steel—24-page booklet containing a very valuable presentation of the application and properties of this steel is just issued by American Cast Iron Pipe Co. Bulletin 386.

Republic Steel Corp.'s second edition of National Emergency Steels tells you all about these new steels. Bulletin 345.

Page after page of useful technical data and reference tables on tool steels. Latrobe Electric Steel Co. Bulletin 367.

Machinery steel selector has been issued by the Elastuf group which includes Horace T. Potts, Brown Wales and Beals, McCarthy & Rogers. Bulletin 256.

Aircraft steels, bearing steels. Rotary Electric Steel Co. Bulletin 24.

Steel Data Sheets. Wheelock, Lovejoy & Co. Bulletin 25.

Molybdenum wrought steels. Molybdenum Corp. of America. Bulletin 26.

Free Machining Steels. Monarch Steel Co. Bulletin 30.

Use Handy Coupon Below for Ordering Helpful Literature. Other Manufacturers' Literature Listed on pages 1187, 1188, 1190, 1192, 1194, 1196, 1198, 1200, 1202 and 1204.

Metal Progress 7301 Euclid Ave., Cleveland 3, Ohio December, 1943

Send me the Literature I have indicated below.

Name .....Title .....

Company .....Address .....

(Students—please write direct to manufacturers).

Check or circle the numbers referring to literature described on these 11 pages.

1	33	60	89	114	141	165	188	213	255	296	325	347	368
2	35	62	91	115	142	167	189	215	256	297	327	348	369
3	38	64	93	116	143	168	190	217	258	298	328	350	371
4	40	65	94	117	144	169	192	221	260	299	329	351	372
5	41	66	95	118	146	170	193	226	261	300	330	352	374
6	42	67	96	119	147	171	194	228	264	301	331	353	375
7	43	68	97	120	148	172	196	230	267	305	332	354	376
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21	51	79	105	133	156	180	204	243	281	318	340	361	384
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30	57	86	110	139	163	186	210	251	292	323	345	366	
31	59	88	112	140	164	187	212	252	294	324	346	367	

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Chemical analyses, shapes and sizes of Joslyn stainless steel products are presented in extras and deductions booklet just issued by Joslyn Mfg. and Supply Co. Bulletin 297.

Tool Steels. Bethlehem Steel Co. Bulletin 31.

Enameling iron sheets. Inland Steel Co. Bulletin 33.

Loose-leaf reference book on molybdenum steels. Climax Molybdenum Co. Bulletin 35.

Low carbon open hearth case carburizing steel. W. J. Holliday & Co. Bulletin 38.

Aircraft Alloy Steels. Joseph T. Ryerson & Son, Inc. Bulletin 40.

Kinite alloy tool steel bar stock and its easy handling in heat treatment are described in leaflet by H. Boker & Co., Inc. Bulletin 258.

New Catalog C makes it easy to get International Nickel Co. literature, as it presents brief description and index to a wide variety of booklets. Bulletin 305.

"Graphitic Booklet" gives complete information on new, free-machining, long-wearing steel. Steel & Tube Div., Timken Roller Bearing Co. Bulletin 307.

Spark Testing Guide—a 21" x 30" wall chart—is useful in segregating tool steel scrap, unscrambling mixed stocks and checking identity of tool steel before heat treatment. Carpenter Steel Co. Bulletin 312.

HWD hot work die steel and Sterling stainless steels are described in four new leaflets by Firth-Sterling Steel Co. Bulletin 323.

Engineering and comparative information on porcelain enameled iron is presented in new illustrated booklet by American Rolling Mill Co. Bulletin 376.

New booklet gives full information on N-A-X high tensile and N-A-X 9100 Series of alloy steels. Great Lakes Steel Corp. Bulletin 328.

Spindle speed calculator is handy chart to figure machining rates on bar steels. Bliss & Laughlin, Inc. Bulletin 333.

New handbook on when, where, how and why to use various types of stainless steel is offered by Rustless Iron and Steel Corp. Bulletin 334.

Attractive new catalog describes the line of steel offered by Peninsular Steel Co. Bulletin 337.

Attractive, illustrated 64-page booklet describes the welding of stainless steels. Allegheny Ludlum Steel Corp. Bulletin 384.

NON-FERROUS METALS

Reynolds Metals Co. has issued two color charts showing marking for identification of wrought aluminum alloy products, rod, bar, tubing and shapes, and for aluminum alloy sheet. Bulletin 294.

Platinum Metal Catalysts. Baker & Co., Inc. Bulletin 41.

Die casting equipment. Lester-Phoenix, Inc. Bulletin 42.

Bronze. Frontier Bronze Corp. Bulletin 44.

Copper Alloys. American Brass Co. Bulletin 45.

Handy & Harman has issued a revised edition of their general catalog on Sil-Fos and Easy-Flo brazing alloys. Bulletin 43.

Cerrosafe, a low temperature melting metal, used to accurately proof-cast cavities. Cerro de Pasco Copper Corp. Bulletin 47.

"The Story of Magnesium," illustrated booklet by the Permanente Metals Corp. Bulletin 261.

Brass and bronze castings. Hammond Brass Works. Bulletin 48.

Reference on properties of lead. St. Joseph Lead Co. Bulletin 49.

6th edition of Revere Weights and Data Handbook. Revere Copper and Brass, Inc. Bulletin 296.

Catalog of brass, bronze and iron alloys. Cramp Brass and Iron Foundries Div., Baldwin Locomotive Works. Bulletin 50.

80-page Duronze Manual, well indexed for reference, presents data on high strength silicon bronzes. Bridgeport Brass Co. Bulletin 52.

Forgeable tin-free bearing metal. Mueller Brass Co. Bulletin 53.

Surface protection for magnesium. American Magnesium Corp. Bulletin 54.

Rare metals, alloys and ores. Foote Mineral Co. Bulletin 56.

Brazing Booklet. Westinghouse Elec. & Mfg. Co. Bulletin 57.

Dowmetal data book. Dow Chemical Co. Bulletin 51.

Two new Ampco Metal data sheets discuss forging Ampco to improve physical characteristics and use of Ampco for non-scratching feed fingers. Bulletin 314.

WELDING

Welding Stainless. Page Steel & Wire Div., American Chain & Cable Co., Inc. Bulletin 59.

Chart explains how to select proper flux for every welding, brazing and soldering job. Krembs & Co. Bulletin 60.

Oxy-acetylene welding and cutting. Linde Air Products Co. Bulletin 62.

Flexarc A-C welders. Westinghouse Electric & Mfg. Co. Bulletin 64.

Welding and brazing of aluminum, a new data book issued by Aluminum Co. of America. Bulletin 66.

Use Handy Coupon on Page 1186 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 1186, 1188, 1190, 1192, 1194, 1196, 1198, 1200, 1202 and 1204.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Data book facts on spot, seam and flash welding ferrous and non-ferrous metals and alloys. P. R. Mallory & Co., Inc. Bulletin 65.

Shield Arc electrodes. McKay Co. Bulletin 67.

New advances in arc welding equipment design. Harnischfeger Corp. Bulletin 68.

Nu-Braze No. 4, an improved silver brazing alloy. Sherman & Co. Bulletin 288.

New JR shape cutting machine is described by National Cylinder Gas Co. Bulletin 233.

New 12-page booklet tells how to fabricate fittings for welded piping by means of flame-cutting and welding. Air Reduction Co. Bulletin 234.

New "200" welder is described by Allis-Chalmers in Bulletin 260.

Atomic-hydrogen arc welding, its application and use, is described by General Electric Co. in new Bulletin 241.

Welding alloys and metals on which they should be used are shown in helpful chart form by Eutectic Welding Alloys Co. Bulletin 242.

32-page catalog describes line of welding equipment offered by Victor Epuipment Co. Bulletin 245.

Advantages and physical characteristics of "No-Wear", a hard-facing material. Callite Tungsten Corp. Bulletin 251.

Hard Facing Alloys. Wall-Colmonoy Corp. Bulletin 29.

New 500 lb. capacity welding positioner for light welding jobs is described by Ransome Machinery Co. Bulletin 313.

Two new hard-facing alloys furnished as welding rods for application by Oxy-Acetylene process are described by the Stoody Co. in Bulletin 325.

New line of welding positioners with dual capacity are described in new booklet by Harnischfeger Corp. Bulletin 350.

Vest pocket guide to correct welding practices is offered by Hobart Brothers Co. Bulletin 351.

Comparable arc welding electrodes for stainless are shown in chart issued by Alloy Rods Co. Bulletin 353.

Attractive, new booklet describes electric resistance welder for aluminum and its alloys. Sciaky Corp. Bulletin 358.

Use Handy Coupon on Page 1186 for Ordering Helpful Literature.
Other Manufacturers' Literature Listed on Pages 1186, 1187, 1190, 1192, 1194, 1196, 1198, 1200, 1202 and 1204.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Helpful electrode color chart is offered by the Arcos Corp. Bulletin 374.

TESTING & INSPECTION

Bibliography of more than 700 papers dealing with the polarographic method of metal analysis and a booklet discussing this equipment is offered by E. H. Sargent & Co. Bulletin 338.

Various methods and specific applications of the measurement of case depth are described in illustrated pamphlet offered by Allen B. DuMont Laboratories, Inc. Bulletin 339.

Precision production tools such as surface plates, angle plates, straight edges, etc., are described in Catalog No. 42 issued by Acme Tool Co. Bulletin 340.

Metallurgical polishing equipment offered by Precision Scientific Corp. is described in illustrated booklet. Bulletin 359.

SR-4 strain gage and illustrations of its many uses. Baldwin Southwark. Bulletin 70.

New book contains wealth of practical, usable information on industrial inspection by x-ray. Westinghouse Electric & Mfg. Co. Bulletin 71.

X-Ray Diffraction Unit. General Electric X-ray Corp. Bulletin 72.

Electric heaters and controls for industrial and laboratory. American instrument Co. Bulletin 75.

Carbon-Meter for rapidly determining carbon at the furnace. E. Leitz, Inc. Bulletin 264.

Inspection of non-magnetic metals with the new Zyglo method. Magnaflux Corp. Bulletin 78.

Industrial radiography with radium. Canadian Radium & Uranium Corp. Bulletin 79.

Gage blocks, comparators, projectors. George Scherr Co. Bulletin 83.

Surface Analyzer. Brush Development Company. Bulletin 88.

Portable Brinell hardness tester and folding Brinell microscope. Andrew King. Bulletin 85.

Universal testing machines and typical uses. Riehle Testing Machine Div., American Machine and Metals, Inc. Bulletin 86.

Dillon tensile tester and the Dillon dynamometer. W. C. Dillon & Co. Bulletin 91.

Optical Aids. Bausch & Lomb Optical Co. Bulletin 94.

Coleman universal spectrophotometer. Wilkens-Anderson Co. Bulletin 95.

Metallographic polishing powder. Conrad Wolff. Bulletin 96.

Metallurgical Equipment. Adolph I. Buehler. Bulletin 97.

Hardness testing equipment. Wilson Mechanical Instrument Co., Inc. Bulletin 98.

Identometer for rapid identification of steel. Dravo Corp. Bulletin 267.

Attractive, illustrated booklet describes Clark Instrument's precision hardness tester. Bulletin 318.

"Radiography of Materials" is title of new 96-page book on industrial radiography. Eastman Kodak Co. Bulletin 331.

Eberbach micro hardness tester is illustrated and described in new booklet by Eberbach & Son Co. Bulletin 269.

Moisture determinations of a wide range of materials with new Moisture Teller instrument are described in new leaflet by Harry W. Dietert Co. Bulletin 299.

New flexible film holder for industrial radiography is illustrated and described in leaflet by Picker X-Ray Corp. Bulletin 300.

Stresscoat, a method of analyzing distribution, direction and value of local strains in any structure by means of formation of characteristic crack patterns in a brittle coating applied to its structure, is described in leaflets issued by Magnaflux Corp. Bulletin 301.

Two new folders describe Searchray 80, new self-contained X-ray unit of North American Philips Co. Bulletin 377.

TEMPERATURE CONTROL

New 29-page catalog — Micromax Electric Control — has just been issued by Leeds & Northrup Co. Bulletin 76.

Potentiometer temperature indicators. Foxboro Co. Bulletin 82.

Micro-Optical Pyrometers. Pyrometer Instrument Co. Bulletin 89.

Use Handy Coupon on Page 1186 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 1186, 1187, 1188, 1192, 1194, 1196, 1198, 1200, 1202 and 1204.

LATERAL VERTICAL REVOLVING

KELEKET INDUSTRIAL X-RAY TUBE STAND

A versatile tube stand that brings the work into range . . .

HERE is a tube stand with a tube that goes back and forth—up and down— and around in a circle! It gives you range and flexibility of movement that brings the work into range.

The tube arm (with 5′ 9″ reach) moves on a ball-bearing carriage with six-foot vertical travel. Target to film distance may be anywhere from 24″ to 96 ″above the floor.

The twin columns are mounted on a ball-bearing plate on which the entire unit may be rotated a full 360 degrees around its vertical axis.

The tube itself, turning 360 degrees on its long axis and 90 degrees on its short axis, can be set at any angle within its surrounding sphere.

With this 12-A KELEKET tube stand, positioning the object becomes of minor importance, as even the most inaccessible parts are within reach. Write for Special Bulletin F-12.

KELLEY-KOETT X-RAY MFG. COMPANY
2441? WEST FOURTH ST., COVINGTON, KY.

PIONEER CREATORS OF *QUALITY* X-RAY EQUIPMENT SINCE 1900

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Pyrometer control of high speed salt baths is described in new booklet by Brown Instrument Co. Bulletin 324.

40-page booklet contains useful technical information on thermometry and thermometers. Bristol Co. Bulletin 321.

New file folder service bulletin on Weaver Furnace Atmosphere Indicator. Claud S. Gordon Co. Bulletin 332.

New condensed catalog gives prices and descriptions of instruments offered by Wheelco Instruments Co. Bulletin 268.

Industrial thermocouples. Arklay S. Richards Co. Bulletin 93.

Pyrometer Controller. Illinois Testing Laboratories, Inc. Bulletin 84.

New leaflet describes valve operator of industrial operation of valves, dampers and other control devices. Automatic Temperature Control Co. Bulletin 381.

HEATING • HEAT TREATMENT

36-page catalog illustrates Kold-Hold line of thermal, sub-zero and stratosphere processing and testing machines. Kold-Hold Mfg. Co. Bulletin 99.

Induction heating. Induction Heating Corp. Bulletin 103.

Internally heated salt bath furnaces and pots. Upton Electric Furnace Div. Bulletin 102.

Easy-selection charts on gas-burning equipment. National Machine Works. Bulletin 105.

8-page pictorial bulletin describes the heat treating service of Continental Industrial Engineers, Inc. Bulletin 107.

Hagan rotary forging furnaces are described in bulletin by George J. Hagan Co. Bulletin 108.

Electric Furnaces. Ajax Electrothermic Corp. Bulletin 106.

Homo method for nitriding is described and illustrated in new 19-page catalog by Leeds & Northrup. Bulletin 100.

Lithco, the chemically-neutral heat treating process, and Lithcarb, the process for fast, bright gas-carburizing. Lithium Corp. Bulletin 101.

Centrifugal blowers and exhausters. Roots-Connersville Blower Corp. Bulletin 270.

Furnaces for heat treatment of aluminum, magnesium and their alloys. Lindberg Engineering Co. Bulletin 271.

Rotary Hearth Furnaces. Lee Wilson Sales Corp. Bulletin 290.

Gas, oil and electric heat treating and carburizing furnaces. Holcroft & Co. Bulletin 114.

Industrial furnaces, equipment for bright annealing stainless steels and ammonia dissociation equipment. Drever Co. Bulletin 115.

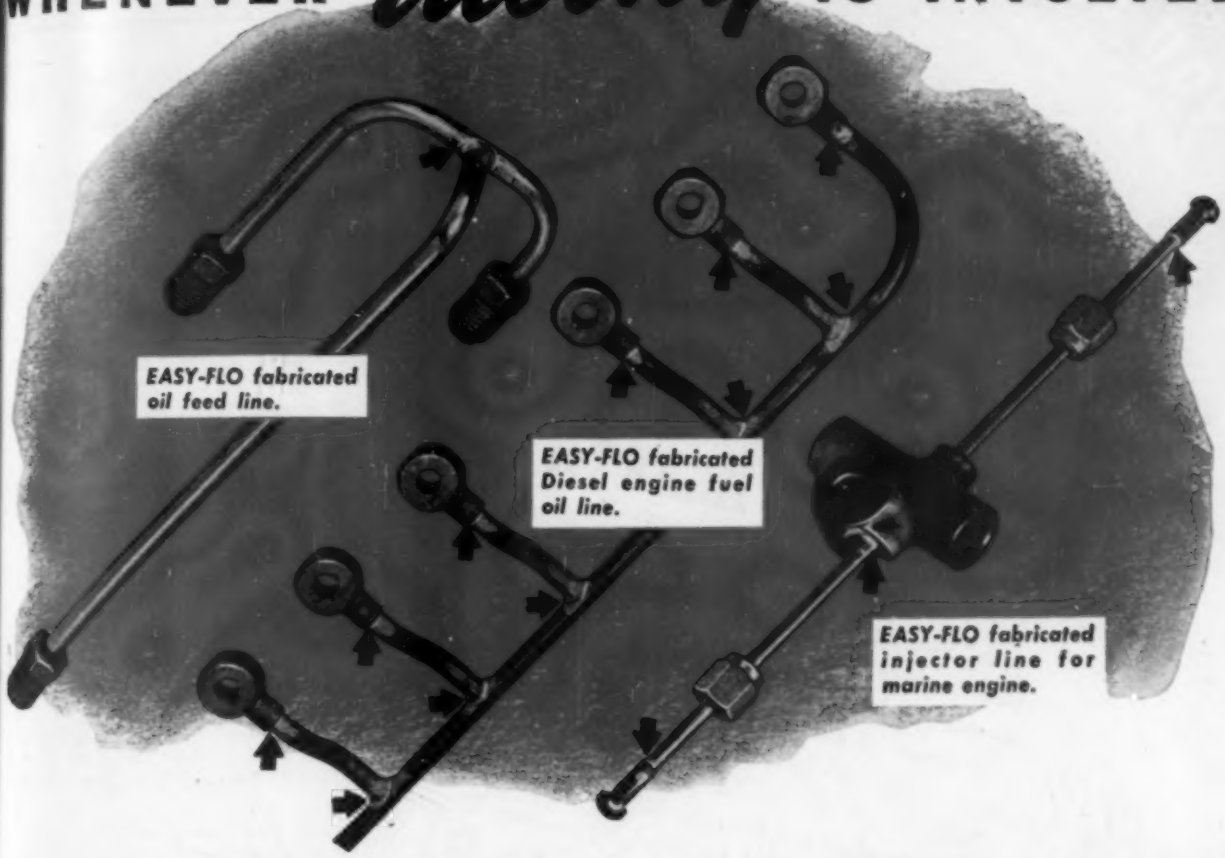
Industrial ovens, rod bakers, welding rod ovens, furnaces. Carl-Mayer Corp. Bulletin 116.

Full muffle and other heat treating furnaces described in catalog by Charles A. Hones, Inc. Bulletin 117.

Non-metallic Electric Heating Elements. Globar Div., Carborundum Co. Bulletin 119.

Use Handy Coupon on Page 1186 for Ordering Helpful Literature.
Other Manufacturers' Literature Listed on Pages 1186, 1187, 1188, 1190, 1194, 1196, 1198, 1200, 1202 and 1204.

WHENEVER *tubing* IS INVOLVED



it will pay you to design for and specify SIL-FOS or EASY-FLO brazing

It will pay because these two low-temperature silver brazing alloys meet every requirement of ferrous and non-ferrous tubing fabrication. They make air, gas and liquid-tight joints with consistent reliability and unequaled speed—joints with the strength and ductility to withstand severe vibration, shock and temperature changes—joints that are high in resistance to most corrosive agents. And they do all this at surprisingly low cost.

Three typical BUNDY TUBING jobs are shown above—all fabricated with EASY-FLO—and all done by girl operators, for it's easy to braze with these exceptionally free-flowing alloys.

BULLETIN 12-A GIVES YOU THE FULL SIL-FOS AND EASY-FLO STORY and much useful metal joining information. Write for your copy now.

ARMY E NAVY

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HANDY & HARMAN

82 FULTON ST., NEW YORK 7, N. Y.

Bridgeport, Conn. • Chicago, Ill. • Los Angeles, Cal. • Providence, R. I. • Toronto, Canada

Agents in Principal Cities

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

56-page vest pocket data book on heat treating practices and procedures. Chicago Flexible Shaft Co. Bulletin 118.

24-page catalog describes gas, oil and electric Holden heat treating pot furnaces, and baths. A. F. Holden Co. Bulletin 120.

Modern electric furnaces for heat treating. Harold E. Trent Co. in new Bulletin 121.

Control of temperatures of quenching baths. Niagara Blower Co. Bulletin 122.

Molten Salt Baths. E. I. DuPont de Nemours & Co., Inc., Electrochemicals Department. Bulletin 123.

Tocco hardening, brazing, annealing and heating machines. Ohio Crankshaft Co. Bulletin 124.

Handling cylinder anhydrous ammonia for metal treaters. Armour Ammonia Works. Bulletin 128.

Industrial Furnaces. W. S. Rockwell Co. Bulletin 133.

Certain Curtain Furnaces. C. I. Hayes, Inc. Bulletin 134.

Air-Oil Ratiotrol for proportioning flow of fuel oil and air to oil burners. North American Mfg. Co. Bulletin 135.

Two new bulletins on vertical carburizers and on carbonia finish. American Gas Furnace Co. Bulletin 139.

Van Norman induction heating units. Van Norman Machine Tool Co. Bulletin 144.

Gas-air premix machine. Eclipse Fuel Engineering Co. Bulletin 138.

Low temperature equipment for aging, shrinking, etc. Deepfreeze Div., Motor Products Corp. Bulletin 140.

Controlled atmosphere furnace. Delaware Tool Steel Corp. Bulletin 141.

Dual-Action quenching oil. Gulf Oil Co. Bulletin 132.

Furnaces. Tate-Jones Co. Bulletin 142.

Industrial Carburetors. C. M. Kemp Mfg. Co. Bulletin 143.

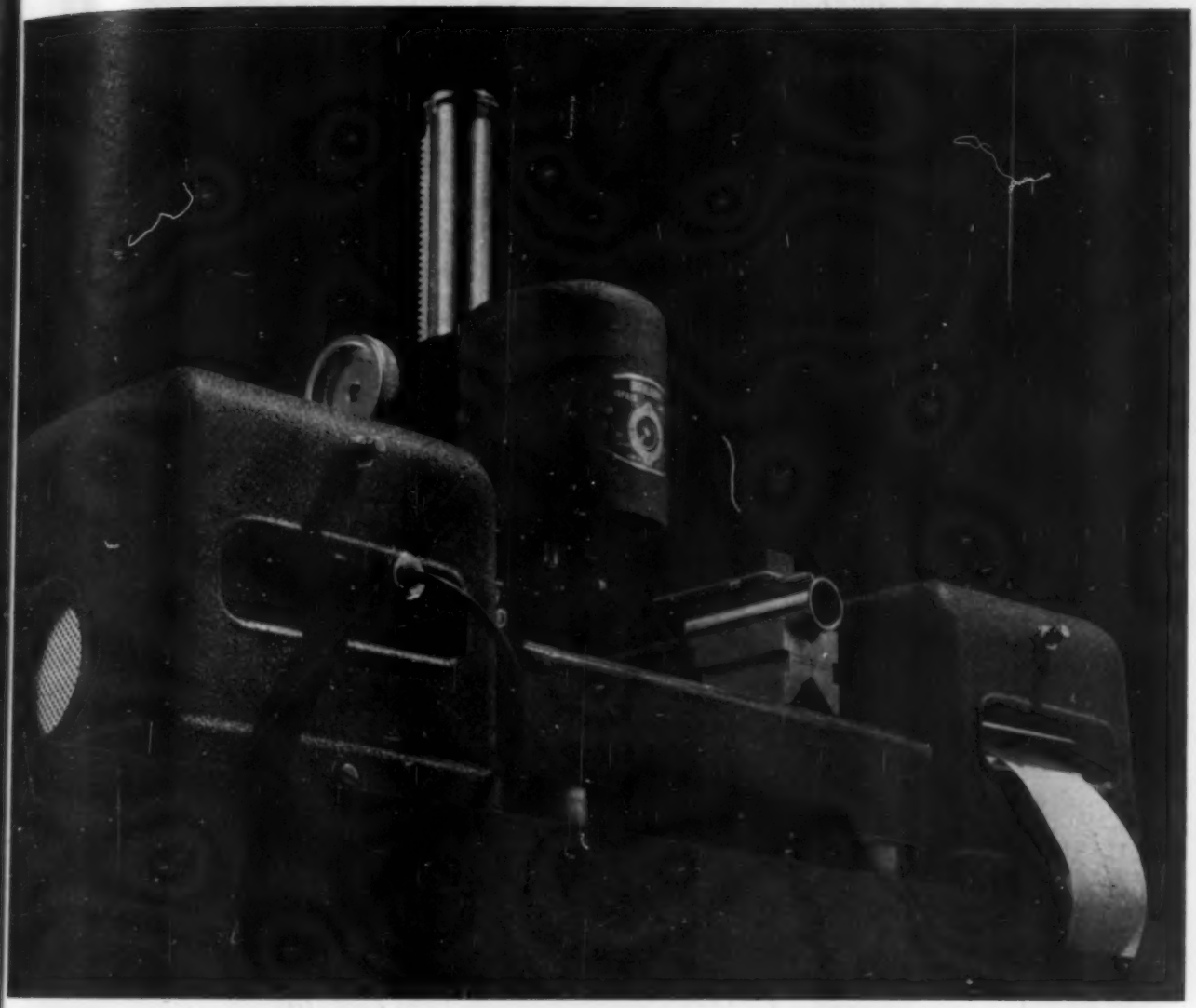
Heat treating, brazing and melting of ferrous and non-ferrous metals. Lepel High Frequency Laboratories, Inc. Bulletin 147.

Vertical Furnace. Sentry Co. Bulletin 148.

Conveyor Furnaces. Electric Furnace Co. Bulletin 149.

Use Handy Coupon on Page 1186 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 1186, 1187, 1188, 1190, 1192, 1196, 1198, 1200, 1202 and 1204.



Precision STARTS WITH LITTLE THINGS • • • AS LITTLE AS .000001"

Surface smoothness (height, depth, pitch of each irregularity) is accurately measured to a millionth of an inch . . . precision at its finest . . . by the Brush Surface Analyzer.

The movement of the diamond stylus is amplified up to 100,000 times and immediately recorded on a moving paper chart for permanent reference.

Readily operated anywhere by plugging into a 110 volt, 60 cycle, A. C. line.

BRUSH CRYSTAL PRODUCTS

THE BRUSH DEVELOPMENT CO.

3311 PERKINS AVENUE • • CLEVELAND, OHIO

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

High and low temperature direct fired furnaces. R-S Products Corp. Bulletin 146.

New Electric Furnace. American Electric Furnace Co. Bulletin 150.

Electric Furnaces for laboratory and production heat treatment. Hoskins Mfg. Co. Bulletin 152.

Furnace Experience. Flinn & Dreffein Co. Bulletin 153.

Flame-type mouth and taper annealing machine for steel cartridge cases. Morrison Engineering Corp. Bulletin 154.

Dehumdifier. Pittsburgh Lectrodryer Corp. Bulletin 155.

No-Carb, a liquid paint for prevention of carburization or decarburization. Park Chemical Co. Bulletin 156.

16-page engineering and data booklet on proportioning oil burners. Hauck Mfg. Co. Bulletin 160.

High Temperature Fans. Michiana Products Corp. Bulletin 158.

Pictorial bulletin describes furnaces for heat treating, normalizing, annealing, forging. Vulcan Corp. Bulletin 161.

Protective combusted atmospheres in Hevi Duty Electric Co. furnaces are discussed in 12-page Bulletin 316.

Turbo-Compressor data book shows how to calculate compressed air systems for a dozen different applications. Spencer Turbine Co. Bulletin 329.

Catalog of heat treating materials. Heatbath Corp. Bulletin 322.

Besides high-speed steel hardening, Ajax Electric Co. Bulletins 110 and 107-A cover the equally impressive Ajax performance in carburizing, neutral hardening, etc. Bulletin 342.

Surface Combustion hardening furnaces for many production requirements are described in new leaflet. Bulletin 352.

Photographs and drawings are used to describe car type quick-anneal oven by Whiting Corp. Bulletin 355.

Standardized sizes of semi-muffle and pot-type furnaces are described and pictured in new leaflet by Dempsey Industrial Furnace Corp. Bulletin 354.

Use of pulverized coal in the metallurgical industries, equipment and designs, are described by Amsler-Morton Co. in Bulletin 361.

Illustrated bulletin on stress-relieving, car-type furnaces. Radiant Combustion. Bulletin 375.

Furnaces for heat treating tool dies and parts are described in new leaflet by Despatch Oven Co. Bulletin 362.

Rapid oil coolers and heat transfer equipment are described in new catalog issued by Bell & Gossett Co. Bulletin 365.

New book "Hardness" describes and evaluates hardness research of noted pioneers, methods of testing and testing instruments. Nitralloy Corp. Bulletin 366.

New booklet describes uniform case hardening up to .150" with controlled carburizing baths. American Cyanamid & Chemical Corp. Bulletin 372.

New leaflet describes and illustrates heat treat furnaces of McCan Furnace Co. Bulletin 379.

82-page catalog describes in detail General Electric heat treat furnaces. Bulletin 380.

Laboratory and tool room furnace Mahr Mfg. Co. in new Bulletin 327.

Four basic heat treating atmospheres are described in new booklet by Westinghouse. Bulletin 383.

War Production Data — 30 pages of useful information on metal working, heat treating and other metal producing operations just issued by E. F. Houghton & Co. Bulletin 38

REFRACTORIES & INSULATION

Insulating firebrick. Babcock & Wilcox Co. Bulletin 162.

Cromox, new protective refractory coating material for prolonging life of firebrick, insulating firebrick, and castable refractories. Federal Refractories Corp. Bulletin 163.

Heavy Duty Refractories. Norton Co. Bulletin 164.

Super Refractories catalog. Carborundum Co. Bulletin 165.

Interesting data sheets on Therm-O-Flake insulating bricks and coatings. Illinois Clay Products Co. Bulletin 298.

Ramix bottom for basic open hearth furnaces. Basic Refractories Inc. Bulletin 168.

Use Handy Coupon on Page 1186 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 1186, 1187, 1188, 1190, 1192, 1194, 1198, 1200, 1202 and 1204.

VAN NORMAN HIGH FREQUENCY INDUCTION HEATING

Section of tube brazed by Van Normanizing. Heating time—6 seconds.

In the illustration, collars are brazed to tubes in 6 seconds with Van Norman High Frequency Induction Heating. Bonds are clean, tight and uniform. The finished part has no discoloration and is free from scale, thus cleaning operations, which are usually necessary when torches and other brazing methods are used, are eliminated, spoilage is minimized, and piece after piece is brazed with the same uniform results. Obviously, VAN NORMANIZING produces a better finished part, speeds output and reduces costs.

By using the proper work-holding fixture and heating coil, a number of workpieces can be brazed simultaneously. Odd-shaped parts are just as easily brazed by Van Norman High Frequency Induction Heating as uniform parts.

It will pay you to investigate Van Norman High Frequency Induction Heating for Hardening, Brazing, Soldering, Annealing and other applications requiring localized heat.

"It pays to Van Normanize"

VAN NORMAN COMPANY
SPRINGFIELD 7, MASSACHUSETTS

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Conductivity and heat transfer charts. Johns-Manville. Bulletin 167.

Brickseal refractory coating. Brickseal Refractory Co. Bulletin 169.

D-E insulating materials and their application are described in new data booklet by Armstrong Cork Co. Bulletin 208.

Corhart Electrocast Refractories for the melting and refining of metals are described by Corhart Refractories Co. Bulletin 209.

Zircon refractories in aluminum open hearth furnaces are discussed in new leaflet by Chas. Taylor Sons Co. Bulletin 347.

H-W magnamix, a Washington magnesite ramming mixture for open hearth and electric steel furnaces, is described in new leaflet by Harbison-Walker Refractories Co. Bulletin 371.

Charts to simplify solution of heat-transfer problems in refractories and high temperature insulation are shown in new 16-page booklet by Atlas Lumnite Cement Co. Bulletin 378.

FINISHING • PLATING • CLEANING

Roto-Finish equipment for deburring, buffing, polishing and coloring. Sturgis Products Co. Bulletin 170.

A protective, deep black finish to steel. Heatbath Corp. Bulletin 171.

Alvey Ferguson Co. shows how various product washing problems were solved. Bulletin 172.

Four new booklets describe blackening processes for metals. Enthone Co. Bulletin 276.

Pickling. Wm. M. Parkin Co. Bulletin 174.

Motor-Generators for electroplating and other electrolytic processes. Columbia Electric Mfg. Co. Bulletin 173.

Detrex metal cleaning machines, metal cleaning chemicals and processing equipment. Detrex Corporation. Bulletin 175.

Electrochemical Descaling. Bullard-Dunn Process Div., Bullard Co. Bulletin 212.

Airless Rotoblast. Pangborn Corp. Bulletin 176.

Cadmium Plating. E. I. duPont deNemours & Co., Inc. Bulletin 177.

Use Handy Coupon on Page 1186 for Ordering Helpful Literature.

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Rust inhibiting wax coatings for protection of metal. S. C. Johnson & Son, Inc. Bulletin 180.

Tumbling and cleaning. Globe Stamping and Machine Co. Bulletin 179.

Catalog on finishing and cleaning. Frederick Gumm Chemical Co., Inc. Bulletin 292.

Resilon corrosion-resistant tank linings and applications are described in 8-page leaflet by United States Stoneware Co. Bulletin 291.

"Indium and Indium Plating". Indium Corp. of America. Bulletin 182.

Service report describes use of Oakite machining, drawing, degreasing and descaling materials. Oakite Products, Inc. Bulletin 210.

Jetal process and its characteristics as a protective coating. Alrose Chemical Co. Bulletin 213.

Catalog section on new sheet Koroseal linings for tanks of welded steel, wood or concrete has been issued by the B. F. Goodrich Co. Bulletin 112.

Lead plating is discussed in new booklet issued by Harshaw Chemical Co. Bulletin 109.

Catalog shows typical cleaning and finishing machines engineered and built by Howard Engineering & Mfg. Co. Bulletin 110.

Four types of solvent degreasers and cleaners are described in new leaflet by Technical Processes Div., Colonial Alloys Co. Bulletin 230.

Discussion of anodizing, chromatizing and phosphatizing in illustrated 60-page book has been issued by Turco Products, Inc. Bulletin 243.

Revised edition of "The American Line", 20-page reference catalog of entire line of products manufactured by American Foundry Equipment Co. has just been released. Bulletin 341.

112-page manual describes Chemicals by Glyco. Glyco Products Co. Bulletin 346.

Cleaning castings and forgings at low cost by tumbling is described in leaflet by Whiting Corp. Bulletin 356.

Illustrated booklet describes blast cleaning equipment offered by Ruemelin Mfg. Co. Bulletin 360.

ENGINEERING • APPLICATIONS • PARTS

Catalog gives complete specification data on Bunting bearings and bars. Bunting Brass & Bronze Co. Bulletin 343.

Heat treating fixtures for pit-type furnaces are shown in new booklet by Driver-Harris Co. Bulletin 363.

Pressed steel pots are described by Bell & Gossett Co. in new Bulletin 364.

54-page booklet, "File 41—Engineering Data Sheets", gives complete facts on Ampco Metal's physical properties and service record. Bulletin 368.

New information sheets on tapered and formed tubes have just been issued by Summerill Tubing Co. Bulletin 369.

Duraspun Centrifugal Castings Duraloy Co. Bulletin 194.

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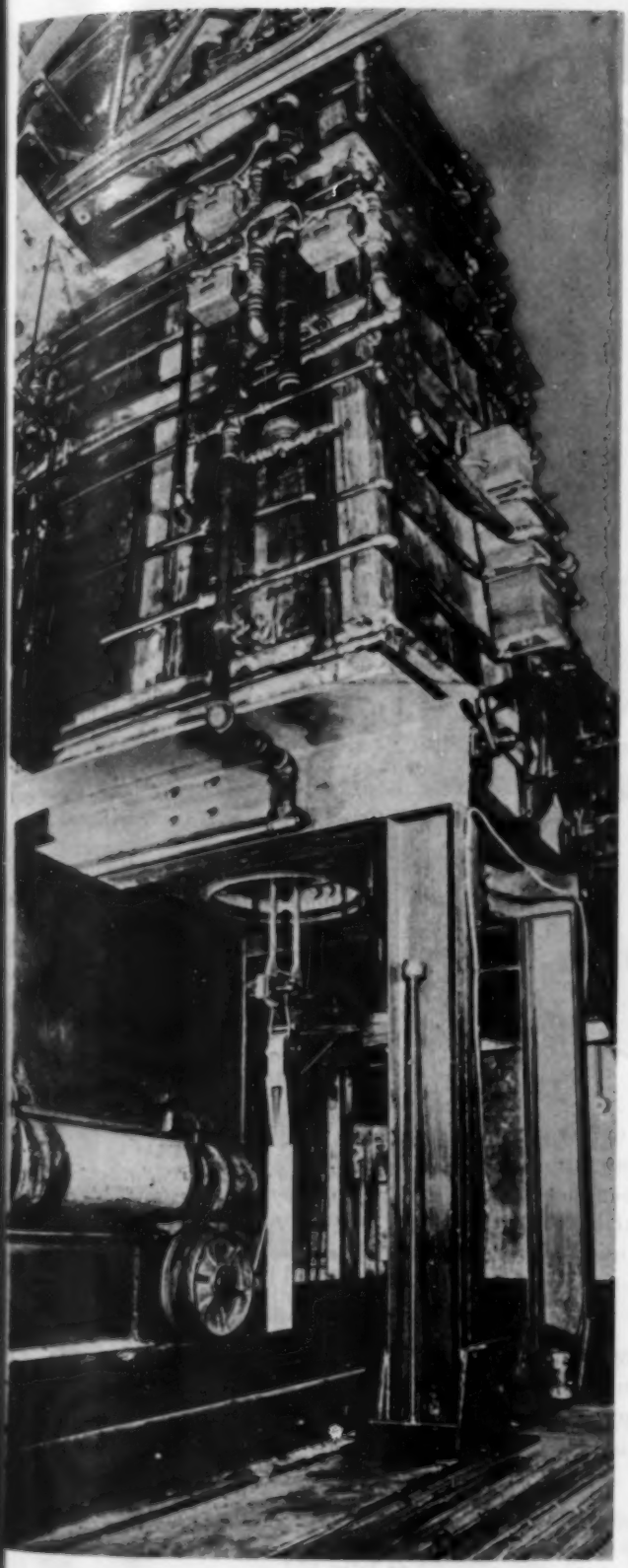
Other Manufacturers' Literature Listed on Pages 1186, 1187, 1188, 1190, 1192, 1194, 1196, 1198, 1202 and 1204.



"Photo" courtesy of Metlab.

Again.. D-H ALLOYS

dependable and heat-resisting...

The parts which are heat-treated in this new "Metlab" furnace are vital to aircraft production. Chromax* and Nichrome* hot rolled rods are used to suspend the work while heating and then lowering directly and vertically into quenching tank.

Chromax*, the heat resisting alloy made by Driver-Harris, like Nichrome*, is available in the form of castings, rods, wire and strip and is described in a booklet "Heat and Corrosion Resisting Alloys" which will be sent upon request.

*Trade Mark Reg. U. S. Pat. Off.

DRIVER-HARRIS COMPANY

HARRISON, NEW JERSEY

"ALLOYS ARE VITAL TO VICTORY"

Branch Offices CHICAGO: 1138 W. Washington Boulevard
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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Chace manganese alloy No. 772 in sheets, strips, rod and special shapes described by W. M. Chace Co. Bulletin 190.

Electrical, corrosion and heat resisting alloys in rod, wire, ribbon and strip forms. Wilbur B. Driver Co. Bulletin 192.

Carburizing Boxes. Pressed Steel Co. Bulletin 193.

Mechanite Castings. Mechanite Research Institute. Bulletin 196.

X-Ray Inspected Castings. Electro Alloys Co. Bulletin 197.

Steel Castings. Chicago Steel Foundry Co. Bulletin 199.

Heat Resisting Alloys. General Alloys Co. Bulletin 200.

Pipes and Tubes. Michigan Steel Casting Co. Bulletin 201.

Bimetals and Electrical Contacts. H. A. Wilson Company. Bulletin 202.

Cr-Ni-Mo Steels. A. Finkl & Sons Co. Bulletin 203.

Industrial baskets, crates, trays and fixtures. Rolock, Inc. Bulletin 204.

Cooper standard alloys. Cooper Alloy Foundry Co. Bulletin 206.

Alloy Castings. Ohio Steel Foundry Co. Bulletin 207.

Flanges and other drop forgings. Ladish Drop Forge Co. Bulletin 221.

Lead-base metals. Magnolia Metal Co. Bulletin 226.

Many applications and savings through use of drop forgings are shown in Drop Forging Topics, issued by Drop Forging Assn. Bulletin 240.

24-page catalog is guide to properties and use of Monsanto plastics. Monsanto Chemical Co. Bulletin 319.

Details of new Chemicast process for small brass parts will be supplied by Chemicast Div., Whip-Mix Corp. Bulletin 330.

MELTING • CASTING • MILL OPERATIONS

Cradle furnace which produces a homogeneous gray iron of uniform chemical analysis, uniform temperature and controlled carbon content is described by Whiting Corp. Bulletin 357.

"Electromet Products and Service" Electro Metallurgical Co. Bulletin 186.

Use Handy Coupon on Page 1186 for Ordering Helpful Literature.

Other Manufacturers' Literature Listed on Pages 1186, 1187, 1188, 1190, 1192, 1194, 1196, 1198, 1200 and 1204.

WHAT'S NEW

IN MANUFACTURERS' LITERATURE

Interesting and helpful information available on the use of alloy pots for heating operation by the Swedish Crucible Steel Co. Bulletin 137.

Crucibles for brass, copper, aluminum and magnesium industries. Electro Refractories and Alloys Corp. Bulletin 183.

Ingot Production. Gathmann Engineering Co. Bulletin 185.

Manganese-Titanium Steels. Titanium Alloy Mfg. Co. Bulletin 184.

Chrom-X for steel mill and foundry. Chromium Mining & Smelting Co. Bulletin 187.

Lectromelt Furnaces. Pittsburgh Lectromelt Furnace Corp. Bulletin 188.

Electric Furnaces. Detroit Electric Furnace Div., Kuhlman Electric Co. Bulletin 189.

Stroman crucible melting furnaces for aluminum and magnesium are described in leaflet by Stroman Furnace & Engineering Co. Bulletin 277.

Operating Features, capacities, charging methods of the Heroult electric furnace. American Bridge Co. Bulletin 215.

Chart for the correction of brasses for zinc loss should interest foundrymen. Foundry Services, Inc. Bulletin 217.

Coke oven plant construction and development in 1942 is described and illustrated in 12-page pamphlet by the Koppers Co. Bulletin 232.

"Fisher Magnesium Scrapbook". Fisher Furnace Co. Bulletin 281.

Attractive booklet describes growth, facilities and offers valuable alloy hints. Niagara Falls Smelting & Refining Corp. Bulletin 246.

Vertical centrifugal casting machine for production of ferrous and nonferrous castings is described by Centrifugal Casting Machine Co. in Bulletin 315.

Interesting, descriptive leaflet on metal reclaiming mill offered by Dreisbach Engineering Corp. Bulletin 284.

GENERAL

New leaflet describes interoffice communication system offered by Executone Communication Systems. Bulletin 385.

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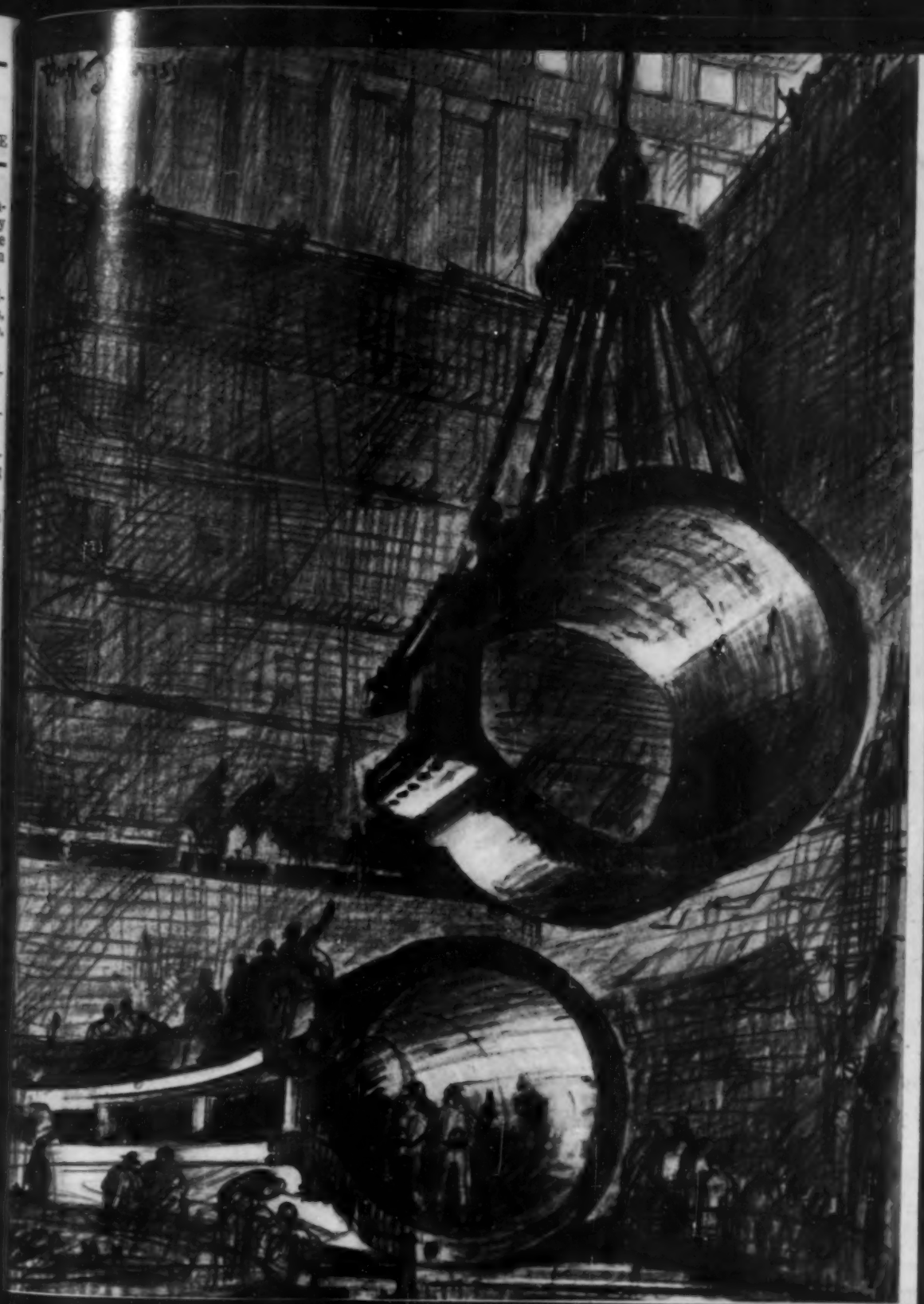
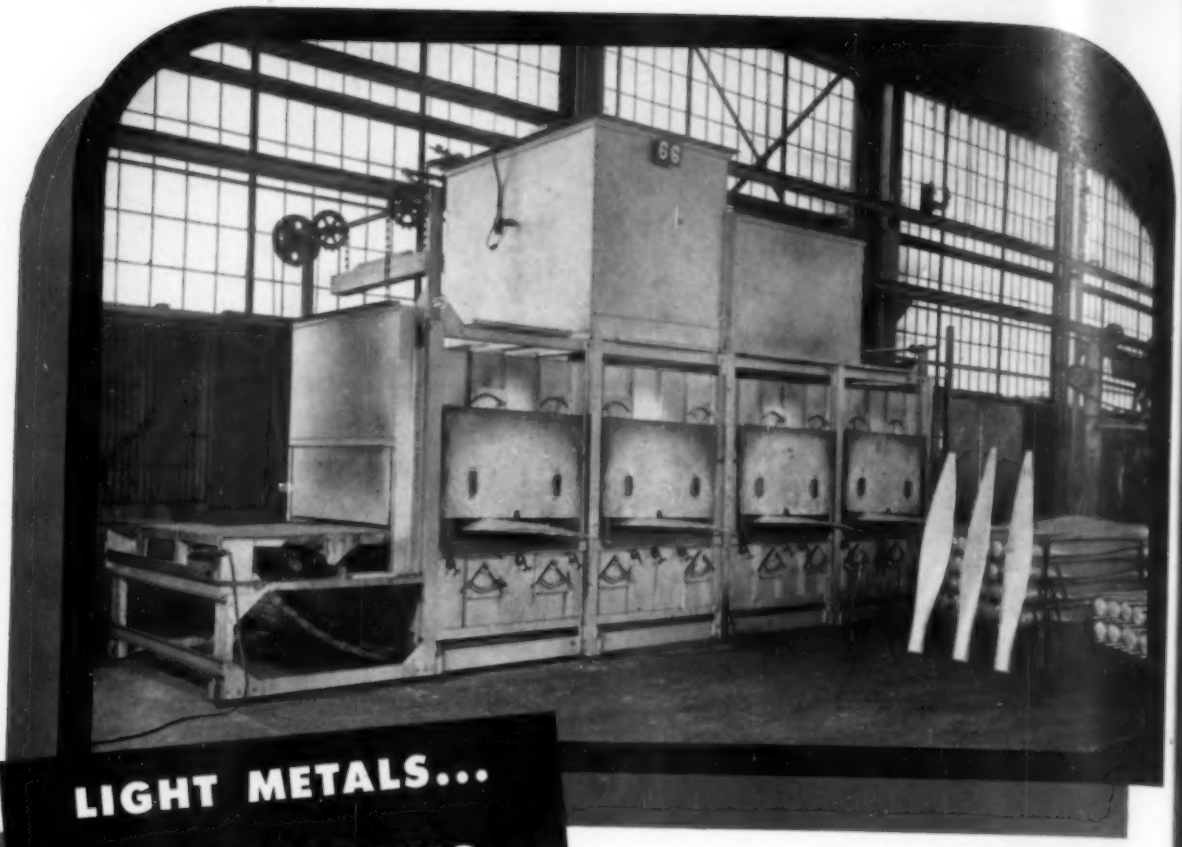
Other Manufacturers' Literature Listed on Pages 1186, 1187, 1188, 1190, 1192, 1194, 1196, 1198, 1200 and 1202.



Metal Progress

DECEMBER. 1943



LIGHT METALS... HEAVY THINKING... NEW FURNACES!

A Surface Combustion combination continuous and batch type furnace, used for heating aluminum parts.

➔ **Why** did one aluminum producer recently order 135 big Surface Combustion furnaces for heating and heat treating of aluminum?

➔ **Why** did one aluminum company early this year buy 5000 Surface Combustion radiant tubes for its furnaces?

➔ **Why** did metallurgists in another plant turn to Surface Combustion for a specially designed experimental furnace—a pilot plant—for heat treating machined and fabricated aluminum parts for airplanes?

➔ ***The answer is:*** They knew Surface Combustion could give them concrete help, ideas that would work.

For 35 years the name of Surface Combustion has stood for new improvements and new techniques in heat treating; Surface Combustion has pioneered in using special atmospheres; has developed the radiant tube, the walking beam, the convection furnace; for 15 years has been the largest manufacturer of gas-fired furnaces in the United States.

Today we are designing and building furnaces of many new types to process aluminum and magnesium and their alloys, furnaces that protect the metals against any kind of surface contamination, furnaces that are really machine tools for light metal production. If you are planning to install a new heat treating furnace for light metals—or any other metals—write or call Surface Combustion.

SURFACE COMBUSTION • TOLEDO, OHIO

SURFACE COMBUSTION

MANUFACTURERS OF SC INDUSTRIAL FURNACES • JANITROL SPACE HEATING EQUIPMENT • KATHABAR SYSTEMS OF HUMIDITY CONTROL

a HARD and FAST rule

TO PRODUCE BETTER PRODUCTS AT LOWER COST

CATERPILLAR Tractor Company's progressive engineers use the "hard and fast rule" of TOCCO Induction Hardening to improve their products and cut costs.

On gears, for example, TOCCO's speedy, localized heating minimizes the distortion problem, permits ***machining first,*** then hardening . . . ***real hardening,*** uncompromised by the need for machining afterward.

Results for the 25.7" diameter, 275-lb. "final drive gear" of Caterpillar's big 17.5-ton D-8 tractor:

LONGER LIFE. TOCCO hardening applies heat-treatment quickly to wearing surfaces, minimizes distortion, permits maximum hardening of gear teeth and thus helps to reduce wear.

SAVES NICKEL. Use of plain carbon steel instead of alloy steel is saving 144,000 lbs. of scarce nickel per year.

CUTS TOOL WEAR. Fellows' shaper cutters had to be reground after four gears. Crown-shaping tools now last for hundreds of gears.

SPEEDS PRODUCTION. Heating time 90 seconds. Quenching time 4 seconds. Floor-to-floor time about 4 minutes per gear.

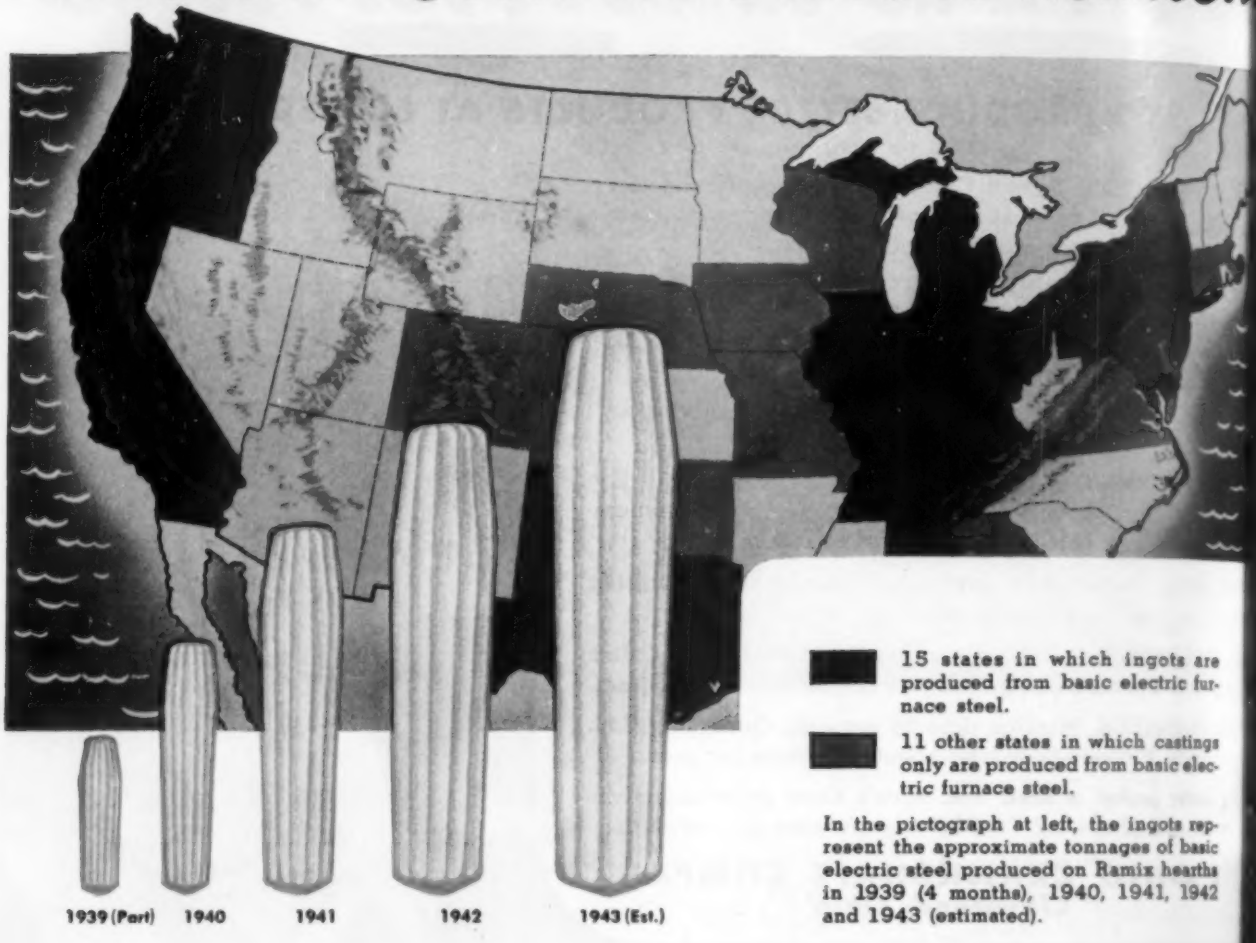
For better product at lower cost. Aren't these *your* objectives . . now and post-war? TOCCO engineers are at your service.

THE OHIO CRANKSHAFT COMPANY
Cleveland, Ohio

TOCCO

HARDENING, BRAZING, ANNEALING, HEATING

Wherever Electric Steel is made..



15 states in which ingots are produced from basic electric furnace steel.

11 other states in which castings only are produced from basic electric furnace steel.

In the pictograph at left, the ingots represent the approximate tonnages of basic electric steel produced on Ramix hearths in 1939 (4 months), 1940, 1941, 1942 and 1943 (estimated).

RAMIX Will Speed Production and Guard Steel Quali

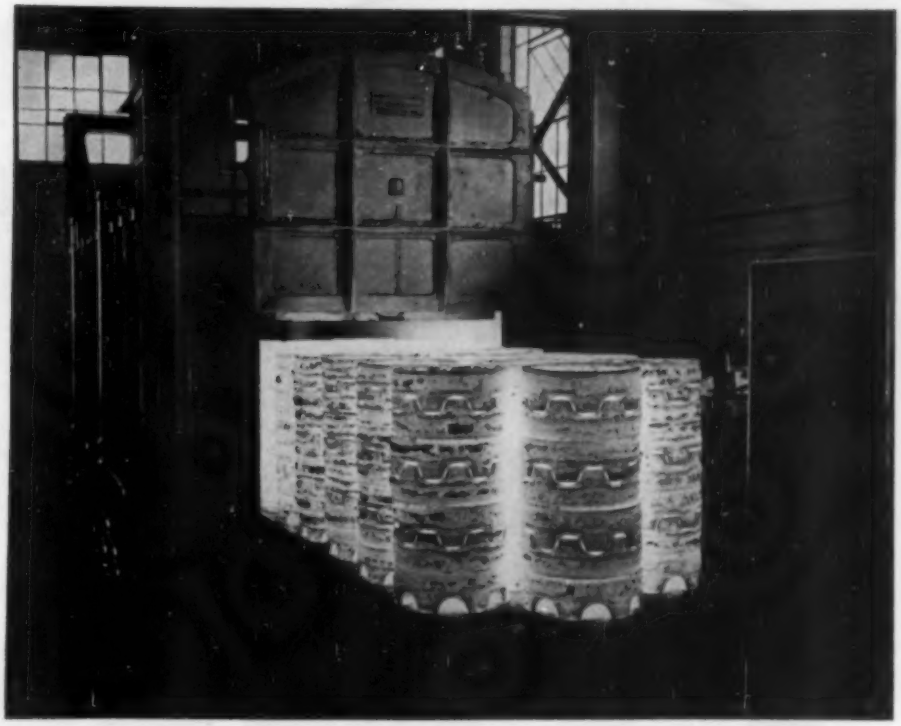
FOUR out of five basic electric steel producers make ingot steel on Ramix bottoms. A majority of steel foundries, too, use Ramix in basic electric furnaces.

Ramix was developed to meet the special conditions encountered in electrics. The first hearth was installed in August, 1939, cold rammed in a small furnace at a northeastern Ohio plant. That shop now has seven Ramix bottoms, representing 331-ton furnace capacity. Another plant has nine Ramix hearths. Over thirty have two or more. Each month sees a steadily mounting number of electric furnace installations.

Ramix, a *non-hydrating product,* is unique among refractories. It is a chemically-bonded magnesia clinker, designed to be cold-rammed—for either major repairs or complete hearth construction. A most obvious advantage is the time and labor it saves in refractory installation. It also means fewer repairs in service, less time for heat-to-heat maintenance and cleaner steel. If you are not yet familiar with all the possibilities of Ramix, why not let a Basic Engineer call at your convenience and tell you the whole story?

BASIC REFRACTORIES, INCORPORATE

CLEVELAND, OHIO



One hundred and fifty rough-forged crank cases for warplane engines, just after being normalized on one of the Massachusetts Steel Treating Co.'s (Worcester, Mass.) National gas-fired furnaces. Temperature limits for all aircraft parts are rigid, and to assure the most dependable control for such vital war work, the temperature is regulated by the Micromax Electric Control Pyrometers shown below.

"TAKE-NO-CHANCES" Policy Leads Heat-Treat Firm to Micromax Pyrometers

Control panel for two two-zone Mass. S. T. Co. furnaces; the Micromax Pyrometers at the rear regulate furnace shown in upper photo; others regulate a smaller furnace. In each case there's a Micromax for the front zone and one for the rear. Each Micromax throttles gas fuel *in strict proportion* to the needs of its end of the furnace, and the result is a control so close that you'd usually need a magnifying-glass to see the "wiggles" in the temperature record.

"Never take a chance with a customer's goods — that's our policy," say the owners of the Massachusetts Steel Treating Co., "and that's why we use Micromax Control Pyrometers on our furnaces. If a customer says 'Heat these forgings to 1700' and we use Micromax Controllers to regulate the heat, we know and our customer knows that we took no chances on that temperature equipment. Nobody even questions it—Micromax is standard for best temperature control."

Several very specific features back up this opinion of Micromax. It is so fully automatic that it runs for days at a time without being touched. It standardizes itself; holds several weeks' supply of ink and chart paper; signals when it needs either ink, chart or dry cells. And it's mechanically more like a machine-tool than an instrument; it has cut gears; thick shafts; sturdy frame castings. The assembly is expertly well-fitted and snug. The entire Pyrometer is designed to take full responsibility for important temperatures, and handle them with complete satisfaction.

If you have a pyrometer problem, an L&N engineer will gladly help solve it. If a catalog meets your present needs, ask for either N-33A on Micromax for Thermocouples, or N-33B, Micromax for Rayotubes.

Ad N-33-620(7)

depends on me!

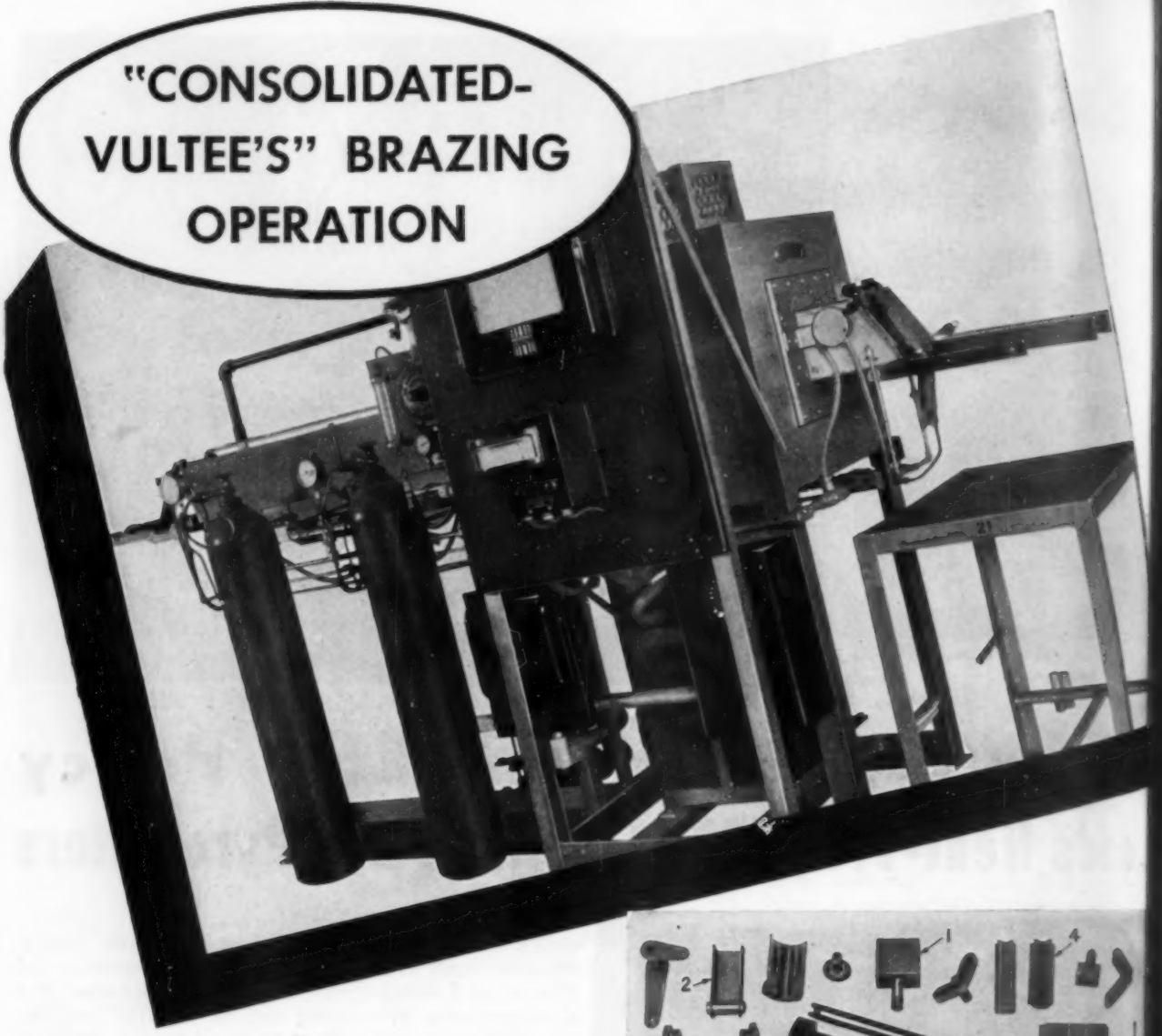
A Slogan For Every American

LEEDS & NORTHRUP COMPANY, 4927 STENTON AVE., PHILA., PA.

LEEDS & NORTHRUP

MEASURING INSTRUMENTS · TELEMETERS · AUTOMATIC CONTROLS · HEAT-TREATING FURNACES

"CONSOLIDATED-VULTEE'S" BRAZING OPERATION



"Consolidated's" savings in time and material, through their use of the above Hoskins Brazing Furnace are shown in the facts below. The brazed parts are shown at the right.

Part No.

1. (*Adapter-Universal Pulley*) Machining eliminated; 40% saving in material.

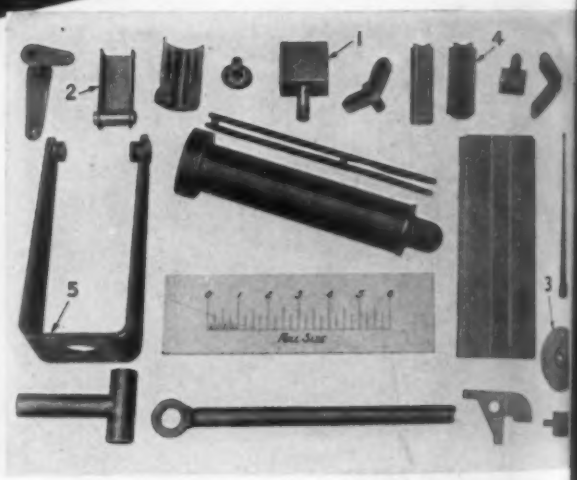
2. (*Channel-Flare Base*) Brazing did away with five previous operations.

3. (*Bearing-Idler Pulley*) Time to make reduced 87%. Eliminated straightening and sand-blasting, and need of skilled welders.

4. (*Hydraulic Valve*) Formerly made of 5 threaded pieces; now merely 2 brazed parts. Saving in material and machine work.

5. (*Gun Yoke*) Brazing eliminated distortion and extra operations, that were associated with welding.

HOSKINS MANUFACTURING CO., DETROIT 8, MICH.



Hoskins Hydrogen Brazing Furnaces are compact; are economical on hydrogen, which is automatically controlled. Ask us for Catalog-58.

HOSKINS PRODUCTS

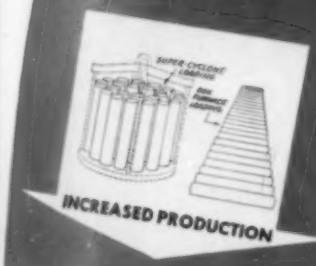
ELECTRIC HEAT TREATING FURNACES • • HEATING ELEMENT ALLOYS • • THERMOCOUPLE AND LEAD WIRE • • PYROMETERS • • WELDING WIRE • • HEAT RESISTANT CASTINGS • • ENAMELING FIXTURES • • SPARK PLUG ELECTRODE WIRE • • SPECIAL ALLOYS OF NICKEL • • PROTECTION TUBES

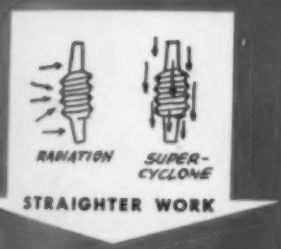
HEATING ELEMENT WIRE — Chromel — NICKEL-CHROMIUM

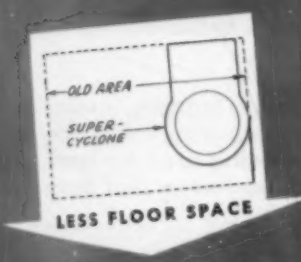
Metal Progress is published and copyrighted, 1943, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $5 a year. Entered as second-class matter Feb. 7, 19[illegible] at the post office at Cleveland, Ohio, under the act of March 3, 18[illegible]

You get these advantages with the

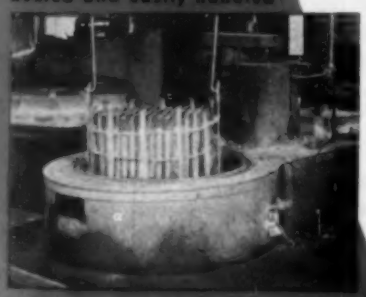
LINDBERG SUPER-CYCLONE







Large loads are accurately heated and easily handled



The revolutionary idea of heating steel to 1750°F. with recirculated air is embodied in the Lindberg Super-Cyclone Furnace. This principle with its accuracy, rapid uniformity and close control of heating offers many advantages, a few of which are listed below.

INCREASED PRODUCTION

The Super-Cyclone Furnace has increased production in the hardening of shells, rifle barrels, flanges, slip yokes, worm gears, bearing races, tank parts and hundreds of similar items. In some cases, production has increased *twelve times* over older methods of heat treating. Bulletin 130 shows how you can figure possible production increases on your own work.

STRAIGHTER WORK

The Super-Cyclone's 100% forced convection heating principle heats the work rapidly and uniformly and eliminates the possibility of one-sided or radiant heat from striking the charge and causing distortion. Straightening time is eliminated or reduced to a minimum. Valuable man hours are released from the press for other work.

LESS FLOOR SPACE

Based on averages of what the Super-Cyclone has done in other plants, you can figure that it will not occupy more than ⅓rd the floor area demanded by conventional equipment to handle the same or greatly increased production.

EXTRA MAN HOURS AVAILABLE

The Super-Cyclone method of handling work on fixtures or in baskets, eliminates the individual handling of parts in heating and quenching. In many plants, lone operators handle large loads through successive steps of heat treatment, for example, forgings are normalized, hardened and tempered in the same Super-Cyclone without being removed from the fixture.

SPECIAL HEATING

Because the Super-Cyclone can be heated at any desired rate to 1750°F. and cooled according to a definite schedule, it is well suited to stress relieving, cycle annealing, malleablizing, and other heating operations requiring a specific cycle. Write for the Super-Cyclone Bulletin 130.

LINDBERG ENGINEERING COMPANY
2448 West Hubbard Street • Chicago 12

ARMY E NAVY

LINDBERG FURNACES

SUPER-CYCLONE for hardening, normalizing, annealing, tempering
CYCLONE for accurate, low-cost tempering and nitriding
HYDRYZING for scale-free and decarb-free hardening

"SWESCO"—The Melting Pot of the Magnesium Industry!

★ ★

PRODUCED BY MASS PRODUCTION IN WEIGHTS FROM 50 to 7500 POUNDS

• Any Size Or Design

WE were well prepared for the coming of the Light Metal Age! For 32 years manufacturers of cast steel melting pots and steel and alloy castings, it was natural for the new Magnesium Industry to look to us for aid in solving many of its problems.

"SWESCO" Cast Steel Melting Pots were specially designed for the Magnesium Industry in size, design, chemical and physical analyses. They have also proved highly satisfactory for cyanide, lead and salt baths. Today, "SWESCO" Cast Steel Melting Pots are being used by leading magnesium smelters, die casters, foundries and incendiary bomb manufacturers. For more detailed information phone, write or wire Dept. SCS-5833 today.

★

GUN MOUNT PEDESTAL

TANK HUB

We're Helping To Smash The Axis— Thru Mass Production of Steel And Alloy Castings From ½ to 7500 Lbs.

It is our "know-how", born of more than a quarter of a century of experience, that is making a vital contribution towards the speedy defeat of the Axis! The Gun Mount Pedestal and Tank Hub illustrated here are but a few of the many important contributions that we are making for Victory!

• SERVING INDUSTRY FOR MORE THAN THIRTY-TWO YEARS

Swedish CRUCIBLE STEEL COMPANY

8561 BUTLER AVENUE . . . DETROIT, MICHIGAN

A DOW MAGNESIUM SERVICE — DIE CASTINGS

Experience — Technique — Equipment

Advancements in the techniques of die casting Dowmetal Magnesium alloys are an integral part of Dow's long and intimate association with magnesium.

Magnesium Die Castings made by Dow offer such advantages as low cost in quantity production, dimensional accuracy, weight saving by ability to cast thin sections and decrease in machining.

Long experience has made Dow the recognized source of authentic information on magnesium—covering a range from ingots to finished products. Regardless of the form of fabrication, if this weight-saving metal is to be used, consult Dow.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

New York · Cleveland · Chicago · St. Louis · Houston · San Francisco
Los Angeles · Seattle

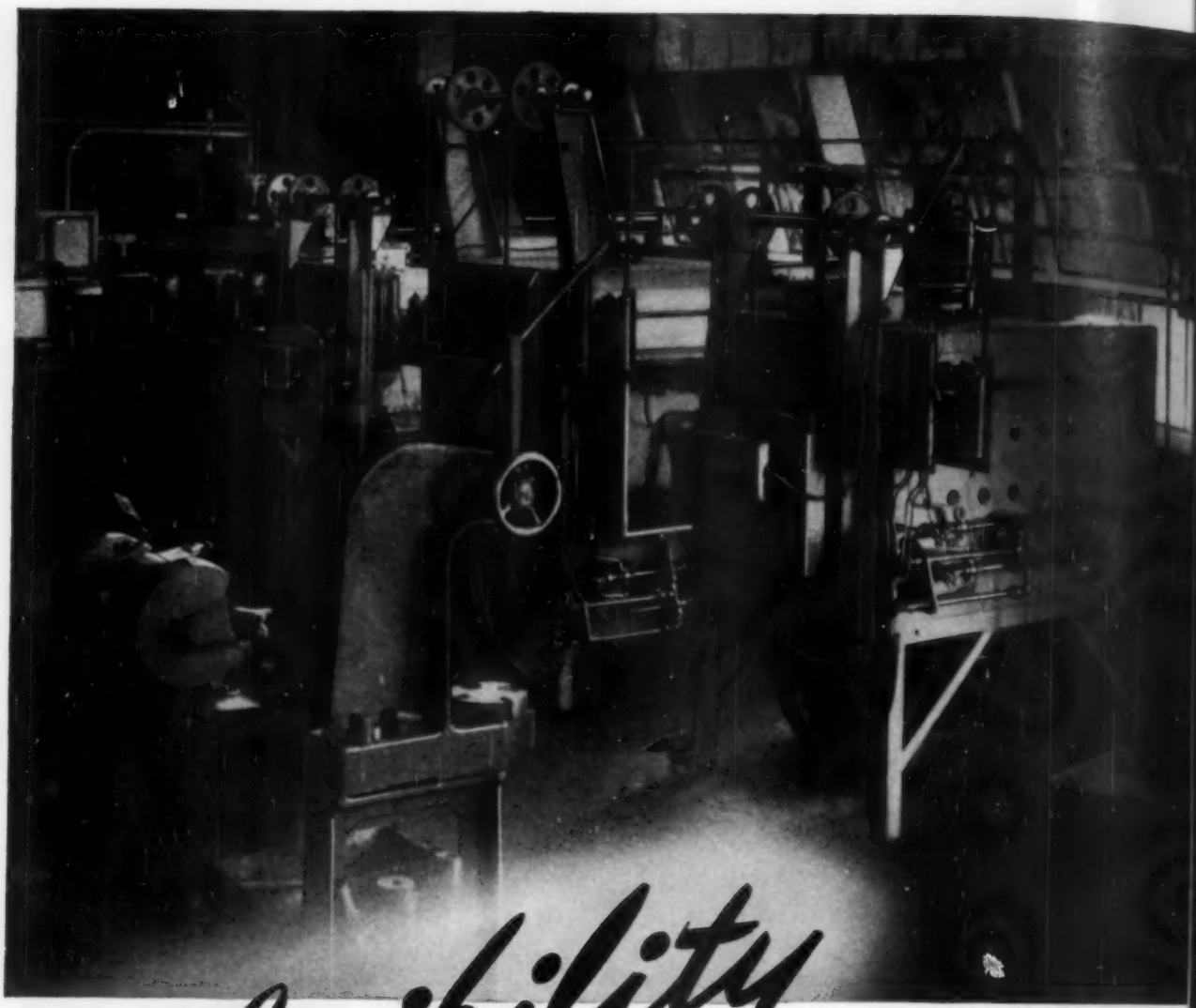
MAGNESIUM

PRODUCER SINCE 1916

DOWMETAL

FROM INGOTS TO FINISHED PRODUCTS

INGOTS · CASTINGS · FORGINGS · SHEET · STRIP · PLATE · EXTRUSIONS



Flexibility IS NECESSARY IN A MAINTENANCE SHOP

The accurate heat treating of production equipment such as turning tools, milling cutters, taps and other special tools and fixtures, plays an important part in keeping production at a high level. The Rock Island Railroad, at their Silvis Maintenance Shop, use three Hevi-Duty Box Furnaces for these varied heat treating operations — Railroads need flexibility in their maintenance shops.

Send for Bulletins HD-341 and HD-441

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES HEVI-DUTY ELECTRIC EXCLUSIVELY

MILWAUKEE, WISCONSIN

BEST DEOXIDIZER

BEST DEGASIFIER

BEST DENSIFIER

CALCIUM BORIDE

for copper, bronze, ferrous and non-ferrous alloys

Of this, YOU are certain - for sound castings, metals must be completely cleaned of *all* gases and oxides. This requires a very *active* agent.

Of this, WE are certain (from users' testimony) - Calcium Boride, an electric furnace product of Electro Refractories and Alloys Corp., is the most thorough deoxidizing, degasifying and densifying agent. It leaves no residual metal impurities, since it is itself insoluble (disappears in form of slag - after reaction). The fluidity of the metal is not affected. Reactive at normal operating temperatures, Calcium Boride does not, therefore, require excessive super heat.

Furnished in a granular form of 6 mesh or finer.

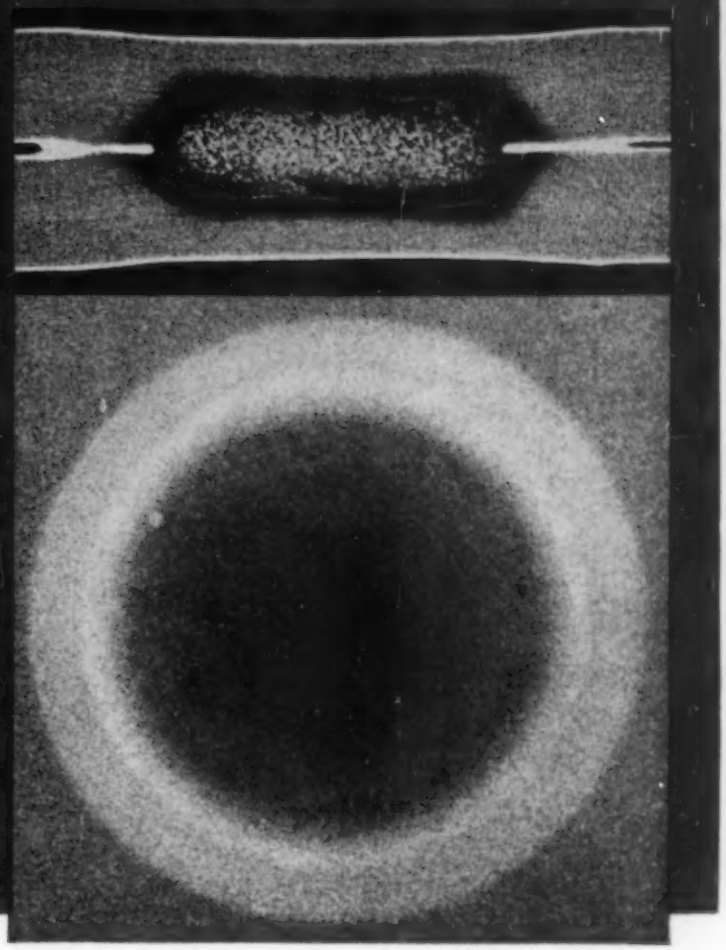
★ *Calcium Boride contains no critical or strategic elements and is, therefore, not under W. P. B. allocation. It is, consequently, specified today more than ever to replace critical materials formerly used for the same purpose.*

ELECTRO REFRACTORIES AND ALLOYS CORP.

EXECUTIVE OFFICES: VARS BUILDING, BUFFALO 2, N. Y.

Manufacturers of Crucibles, Alloys, Stoppers, Refractories, Grinding Wheels

How good is that *Spot Weld?*



Above: Micrograph of cross section of spot welded Alclad 24S-T sheet. 10X. Below: Radiograph of the same weld, enlarged to diameter equal to the above.

Metallographic examination tells you how good a spot weld you've made, but it destroys the sample. Radiographic inspection is nondestructive. Employ both methods, therefore, to establish good welding procedures. Then use occasional radiographic inspection to check production.

Size of the weld nugget, shape, soundness and freedom from cracking are the characteristics which have the most influence on the performance of a spot weld. Radiographs can be made so that they disclose these details.

Techniques for producing good resolution in radiographs have been developed at Aluminum Research Laboratories. Information on these practices is offered by Alcoa to all fabricators of aluminum alloys to enable them to improve their products.

Send for the paper, "Correlation of Metallographic and Radiographic Examinations of Spot Welds in Aluminum Alloys." It describes methods used and results obtained. Write ALUMINUM COMPANY OF AMERICA, 2101 Gulf Building, Pittsburgh, Pennsylvania.

ALCOA ALUMINUM

8 WAYS TO GET BETTER STEEL CASTINGS *Quicker*

1 Anticipate your needs. Give your foundry as much time as possible—they are busy, too. It will help them to know what you need and when you will need it.

2 Whenever possible, avoid special alloys and specifications. Standard specifications are quicker to produce and deliver, especially under war conditions.

3 You'll get better castings—quicker—if you don't expect your foundry to cast parts designed for other methods of production.

4 Consult your foundryman on designs. Often he can make contributions that result in better castings—in less time and at lower cost.

5 Consult your foundryman on patterns—or let him make patterns for you. Proper proportioning of casting members, and proper gates and risers always mean sounder castings.

6 Be sure to give your foundry full and complete specifications, particularly when special testing of castings is required.

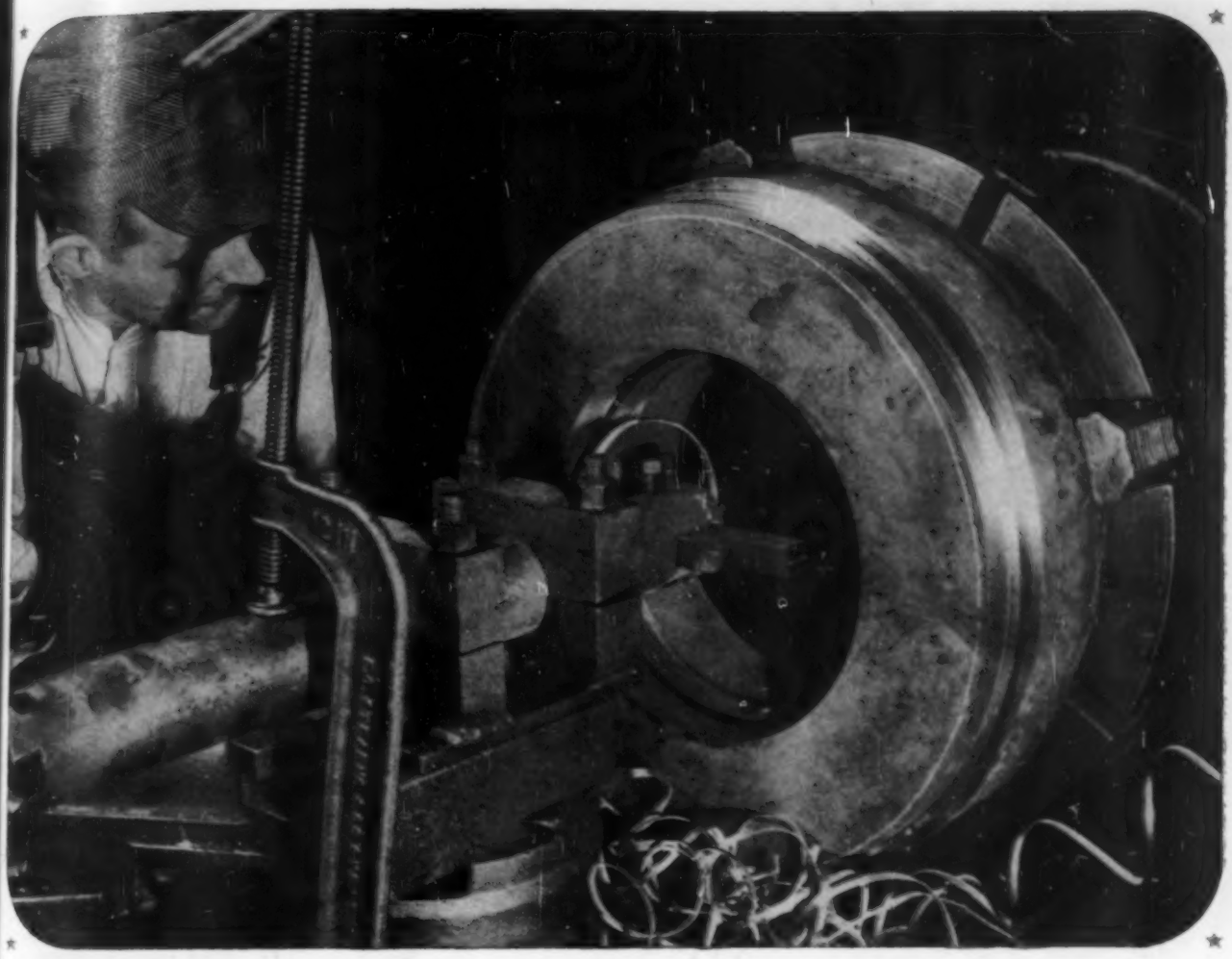
7 Specify deliveries that meet your actual production schedules. Don't hoard castings—you may be crippling another plant's production.

8 Look upon your foundryman as a part of your own organization. Work with him—in full cooperation—you are both trying to WIN THE WAR.

Steel Founders' Society of America · Cleveland, Ohio

MODERNIZE AND IMPROVE YOUR PRODUCT WITH

STEEL CASTINGS



Ready Now FOR YOUR *Super* CUTTING JOBS ...*Super DBL* HIGH SPEED STEEL

NO COMPLICATIONS IN HEAT TREATMENT OR HANDLING

For any shop man familiar with the techniques used on tungsten cobalt steels, or on the 18-4-1 and tungsten-moly analyses, there will be nothing new in the handling and treatment of *Super DBL*. It also conforms to standard in the forms and finishes available, which include regular sizes of mill-treated tool bits and can be supplied from Allegheny Ludlum warehouse stocks, as well as distributors, in principal cities coast to coast.

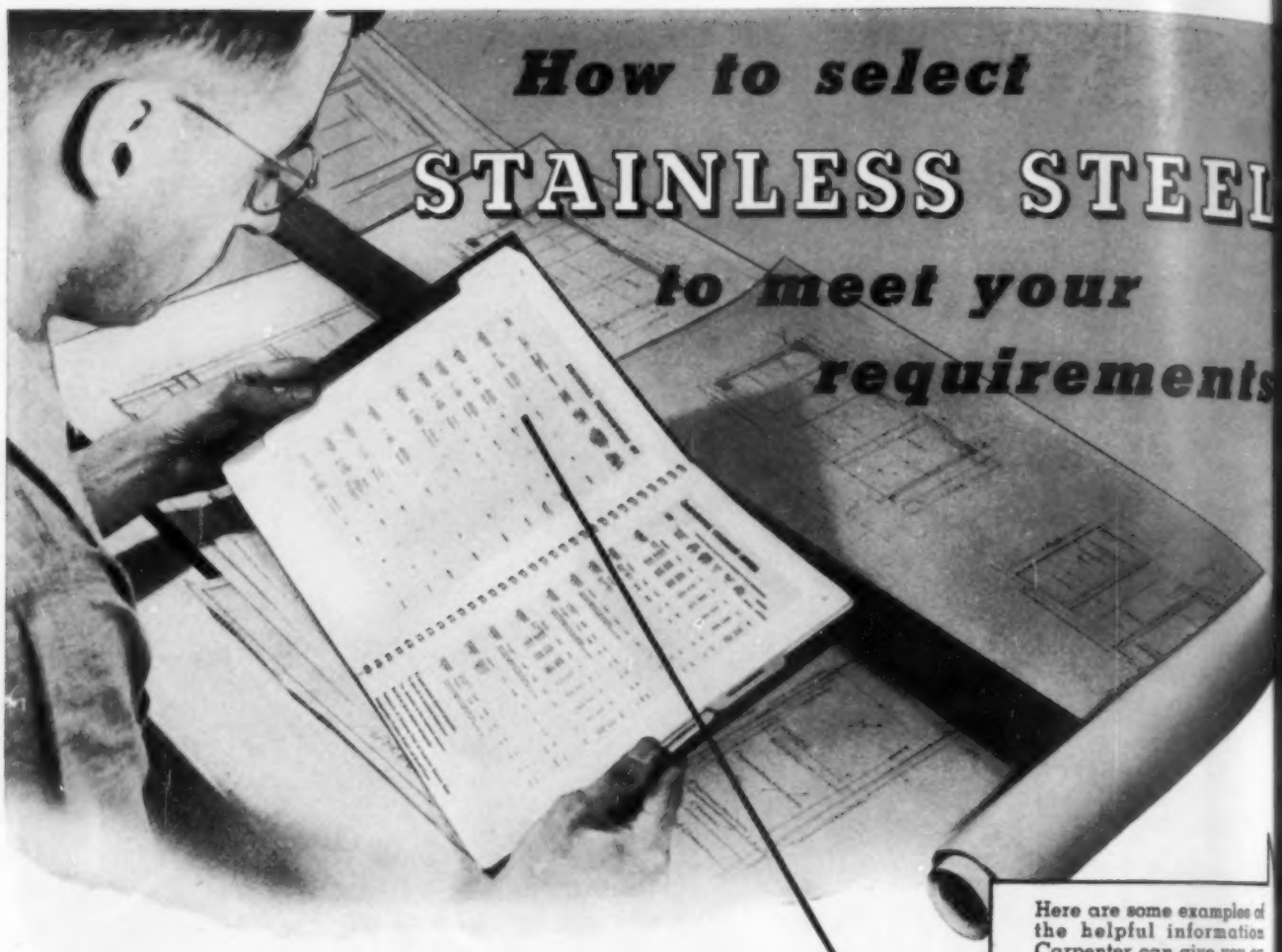
ALLEGHENY LUDLUM mill technicians developed this new High Speed Steel to fill a dual role: first, to meet government requirements for the conservation of strategic materials; and second, to give you a higher degree of hardness and cutting stamina than has been previously available in steels which meet the conservation need.

Super DBL (a low-tungsten, molybdenum, cobalt steel) has been thoroughly tried and tested in service—it's ready to take on your heaviest-duty production work. Use it on hard, gritty castings—on heat treated alloy or stainless steels—on any rough and tough cutting job in the shop with full assurance of maximum red hardness and performance. ● For full data on properties, treatment and use, write for the *"Super DBL* Blue Sheet."

ADDRESS DEPT. MP-6

Allegheny Ludlum
STEEL CORPORATION
BRACKENRIDGE, PENNSYLVANIA

A-9074 . . . W&D

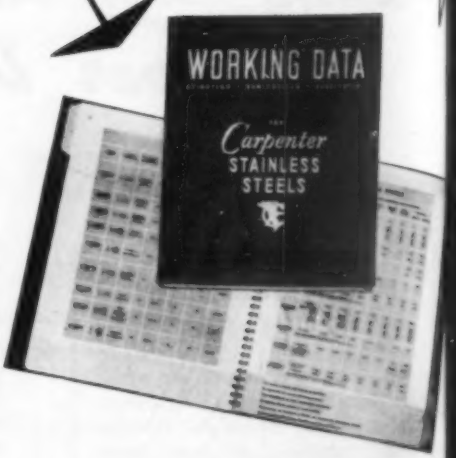


In giving your old or new products the benefits and advantages of Stainless Steel, it is necessary to decide what physical properties, corrosion resistance, and fabricating qualities are needed to meet your specific job requirements.

The popular 18-8 Stainless Steels provide exceptional physical properties, maximum corrosion resistance and excellent fabricating characteristics. There are many applications where these Stainless types can be used to give products longer life and greater utility on the job. To get the most out of 18-8 Stainless, it will pay you to consult Carpenter, who pioneered the development of Stainless Steels, and who, for years, has been helping to solve the problems of Stainless users.

For complete information on all types of Stainless available from Carpenter, write us for a copy of the helpful 98-page book, "Working Data for Carpenter Stainless Steels". This book simplifies the selection, engineering and fabrication of Stainless Steels. It is free to Stainless users in the U. S. A. Just drop us a line on your company letterhead.

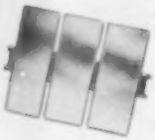
Here are some examples of the helpful information Carpenter can give you on certain types of Stainless to meet specific conditions. These 18-8 types are non-magnetic and are hardenable only by cold working.



THE CARPENTER STEEL COMPANY • 133 W. BERN STREET • READING, PA.

For Greater Strength and Extra Corrosion Resistance in Stainless Parts

CARPENTER STAINLESS NO. 4—TYPE 302



This popular 18-8 type is extremely tough and ductile, and is used in many parts such as stampings, conveyor chains, springs and many cold headed products. Carpenter Stainless No. 4 finds wide application in the form of strip and wire for cold heading purposes. It resists corrosion from all foodstuffs, sterilizing solutions, most of the organic chemicals and dyestuffs, and a wide variety of inorganic chemicals.

Fabricating Qualities: No. 4 responds easily to forging, deep drawing, bending, forming and upsetting both hot and cold. If formed hot or welded, a corrective anneal is required after fabrication to secure the best corrosion resistance. If a corrective anneal after welding or forging is impossible, use Carpenter Stainless 4-Ti or 4-Cb. The satin-smooth ABC finish on No. 4 strip often makes polishing unnecessary. As this Stainless is difficult to machine, parts that require considerable machining should be made from Carpenter (Free-Machining) Stainless No. 8.

Faster Output—Fewer Rejects of Machined Parts

CARPENTER STAINLESS NO. 8—TYPE 303

This Stainless is a Free-Machining 18-8 chrome-nickel steel, used for automatic screw machine parts, valve parts, aircraft engine parts, etc. From the standpoint of corrosion and scale resistance, Carpenter Stainless No. 8 may be used interchangeably with Carpenter Stainless No. 4. This Stainless can be readily forged, machines about like SAE 3120, 4615, etc., and is easy to grind or polish. For deep drawn or cold headed parts, Carpenter Stainless No. 4 is recommended.

Physical Properties Comparable to Carpenter Stainless No. 4.

To Meet Severe Corrosion Requirements

Carpenter Stainless No. 4-Mo (Type 316) is used in pickling racks, circulating pumps, to combat many chemicals, such as sulphurous acid compounds employed in the process industries. Those chemicals which are partially resisted by No. 4 are usually better resisted by No. 4-Mo. It is therefore the logical metal to try where No. 4 is good—but not good enough.

See Physical Properties for Carpenter Stainless No. 4.

Physical Properties of Carpenter Stainless No. 4

TYPE 302—(CARBON .10%—CHROMIUM 18.00%—NICKEL 8.00%)

Tensile Strength—85,000 to 225,000 lbs. per sq. in.

Specific gravity—7.93.

Melting point—Approximately 2550°F.

Specific Heat—.12.

Thermal Conductivity—.052 C.G.S. units at room temperature.

Coefficient thermal expansion—.0000095 average 68°F. to 1500°F. (this is about 50% higher than mild steel or the simple chromium Stainless Steels).

Specific electrical resistance—417 ohms per cir. mil foot at 68°F. Temperature coefficient—.000425 per deg. F. between 68°F. and 1500°F.

Magnetic properties—Nonmagnetic unless work-hardened, when it becomes slightly magnetic.

Permeability—As annealed=1.003 max.

Elastic modulus—29,000,000.

NOTE: The physical properties of all grades of Stainless Steel depend upon form, heat treatment or cold working. Wider ranges of properties are available in certain forms. Take up your special problems with our representative.

For Heat Resistance and Specific Welding Qualities

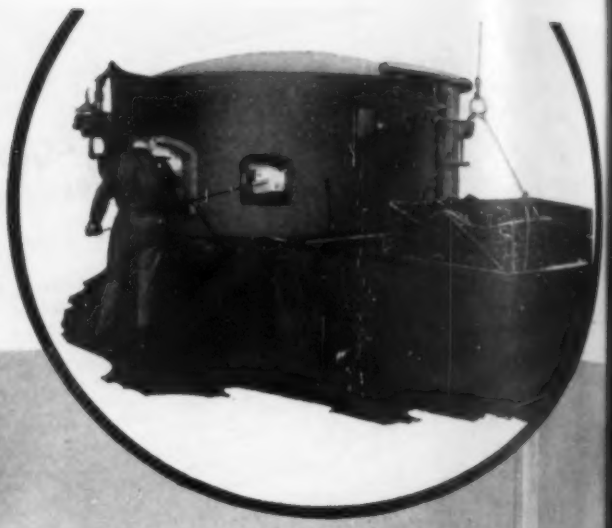
Carpenter Stainless No. 4-Ti (Type 321) and No. 4-Cb (Type 347), were developed for one and the same purpose . . . to strengthen the 18-8 chrome-nickel steels against damage when used within the "danger zone"—800°F. to 1400°F. These grades are especially applicable to aircraft exhaust manifolds and forged or welded parts that cannot be given a subsequent anneal.

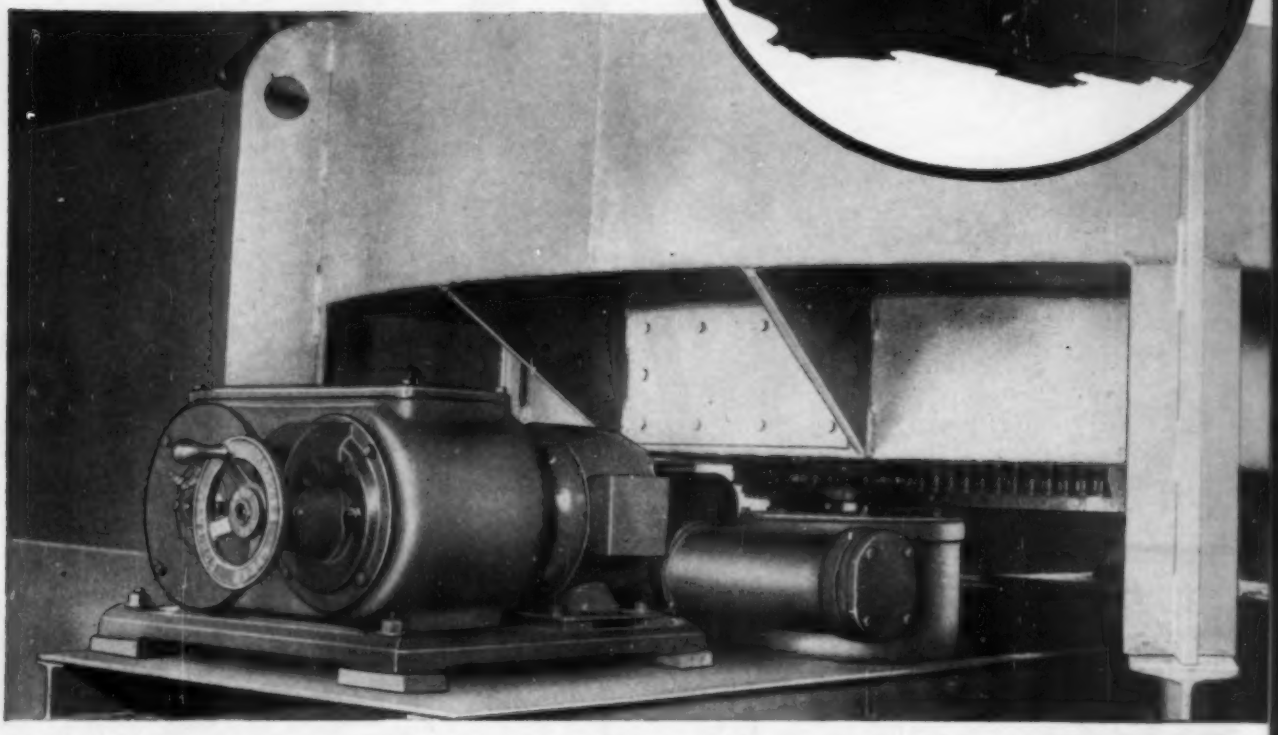
See Physical Properties for Carpenter Stainless No. 4.

Carpenter STAINLESS STEELS

BRANCHES AT Chicago, Cleveland, Detroit, Hartford, St. Louis, Indianapolis, New York, Philadelphia

SOMETHING NEW...





USE RADIANT COMBUSTION ROTARY FURNACES FOR 10 GOOD REASONS

Not only can you depend upon high production and uniform heat treating with Radiant Combustion furnaces . . . you can also be sure of long, trouble-free service. Here are the outstanding reasons:

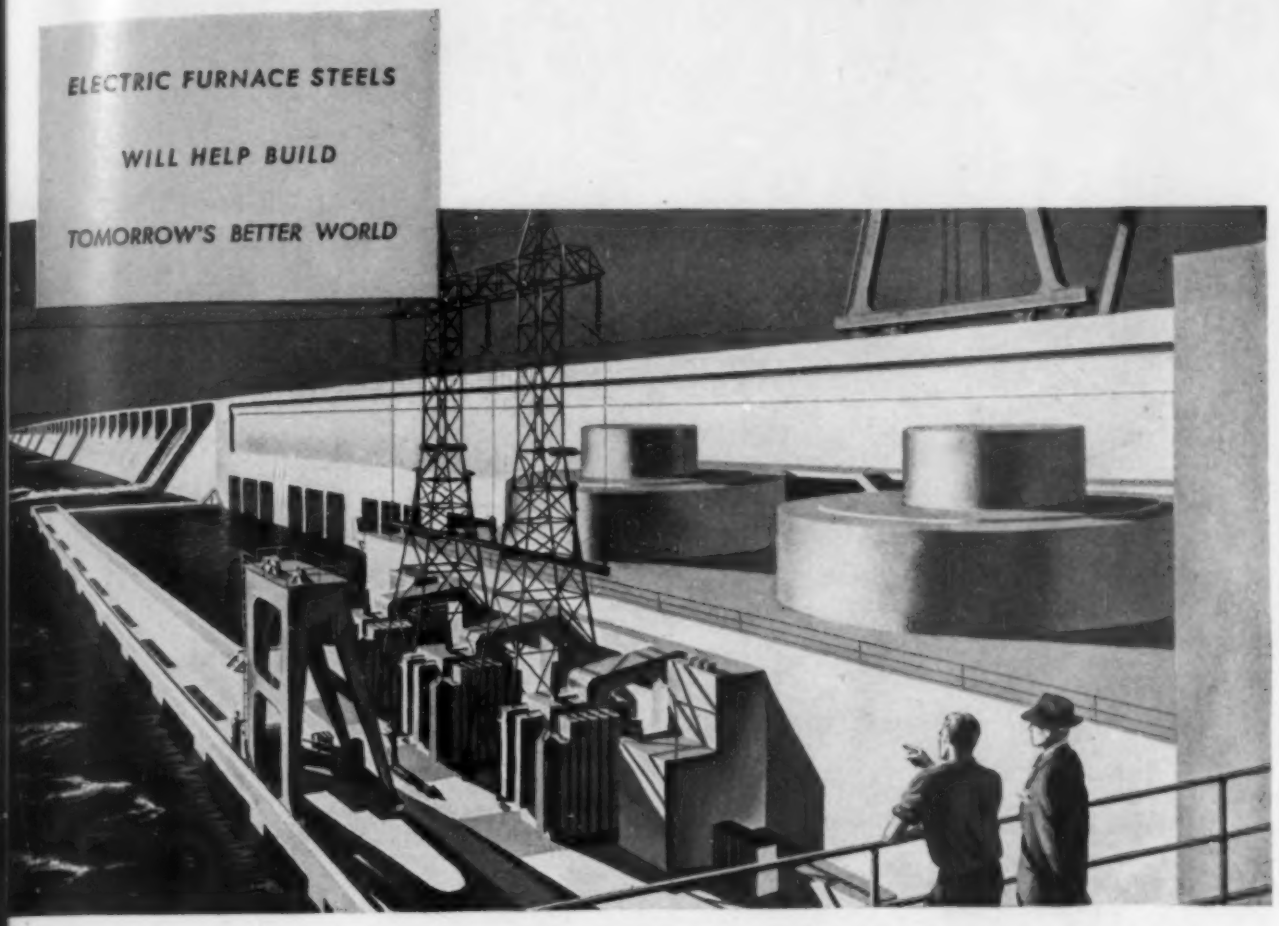
1. Floating gear with fully enclosed drive
2. Three point bearing suspension of hearth on heavy roller bearings eliminates rocking of hearth
3. Specially constructed, interlocked hearth that will not "grow"
4. Double water seal—one for hearth and one for frame
5. Designed to be able to raise shell 8″ to 10″ to clear hearth when jammed
6. Heavy boiler plate shell used, thus eliminating buck-stays
7. Adjustable alloy entrance hearth adjustable from outside
8. Independent arch support. Arch does not rest on walls
9. Heavy I Beam Base eliminates necessity of special foundation
10. Heavy roller bearing to centralize hearth.

Now you know why Radiant Combustion can proudly claim a bigger percentage of new rotary furnace customers than any other manufacturer. *Write today for worth-while literature.* And remember, your furnace will be delivered ON TIME.

Radiant Combustion, Inc

BUILDERS OF EVERY TYPE OF HEAT TREATING FURNACE

WARREN, OHIO



Electrical Magic—for Tomorrow

Snap a switch—turn a button—break a beam of light tomorrow—and electricity will perform new feats of magic. You'll hear and see events happening miles away. You'll enjoy countless conveniences—including better heating, cooking, air conditioning, illumination, refrigeration. Your work will be easier—the products you make better and cheaper—because of electricity.

Few are the tasks that this invaluable servant of man cannot do—will not do—tomorrow. And Republic Electric Furnace Steels which, in vital parts of generating equipment, have helped make possible low cost electrical current, will continue to assist engineers both in the economical production and efficient utilization of electricity.

Republic Electric Furnace Steels—special steels, alloy steels, "aircraft quality" steels and stainless steels—have given engineers and manufacturers the means to accomplish many amazing mechanical achievements. They are responsible to a large extent for the superiority of American fighting machines today.

These steels are exceptionally tough—high in strength to weight ratio. They maintain established limits of hardenability and machinability. They dependably resist abrasion, corrosion, oxidation and fatigue.

They do difficult tasks well—*CONSISTENTLY.* The extremely close control possible only in the electric furnace assures that each of these "targeted steels" will unvaryingly hit the mark at which it originally was aimed—whether a product or processing specification.

And by hitting the mark without fail—by performing with repeated accuracy—these steels enable manufacturers to realize the objective of mass production methods—lower costs.

Always the leader in this field of steel making, Republic has increased its electric furnace capacity more than 900% to meet wartime demands. Tomorrow—when peace arrives—this abundant supply of fine steels will enable manufacturers to profitably produce better things to live with and to work with—in industry, in the home, on the farm. Republic Steel Corporation, General Offices—Cleveland 1, Ohio. Export Department: Chrysler Building, New York 17, N. Y.

REPUBLIC

ELECTRIC FURNACE STEELS

alloy...stainless..."aircraft quality"

—for vital working and structural parts in the automotive, aviation, farm implement, machine tool, petroleum, railroad, chemical, food processing, marine, textile, refrigeration, heavy machinery, electrical, transit and general manufacturing industries.

THE DAILY GRIND

The helicopter relies on special tapered tubing for rotor blade spars. Tubing also goes into the fuselage, and vast amounts are used for landing gear, engine mounts and other parts of military aircraft. Although our facilities are devoted 100% to the war effort, the services of our research and engineering departments are available to designers and others interested in materials. Experimental lots can be produced.

Although Summerill regularly produces cold drawn tubing to highly accurate dimensions, many parts made from tubing require tolerances or finishes that are obtainable only by grinding. The volume of this type of work for war requirements keeps Summerill grinders busy 24 hours a day, 7 days a week.

Tubing which is to be ground to finished size is produced with sufficient oversize to meet minimum wall requirements. Yet the excess metal to be removed must be held to the lowest possible amount necessary to insure a perfect surface. The removal of unnecessary metal would mean a waste of both metal and machine time. This work requires a constant vigilance on the part of the surface grinder operator in checking both fit, size and finish. He must also be capable of setting his machine correctly for each job and know how to keep it in proper working condition.

The painstaking skill and endless effort of Summerill grinding machine operators result in the production of more tubing from the same number of machines. This accomplishment is a reflection of the spirit and desire to excel which permeate the entire Summerill organization.

SUMMERILL TUBING CO.

Bridgeport · Montgomery County · Penna.

E NAVY

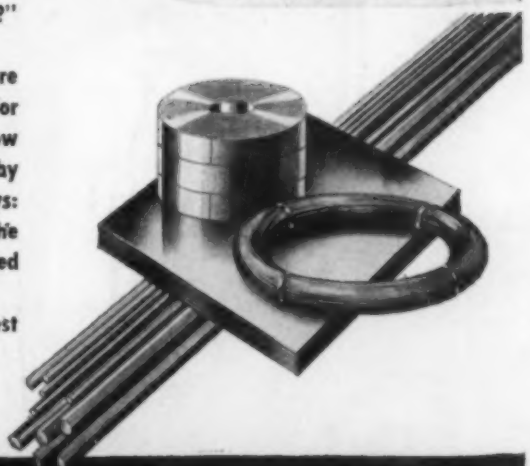
SUMMERILL TUBING COMPANY

Affiliated with EDGAR T. WARD'S SONS CO. and COLUMBIA STEEL & SHAFTING CO.

When the flame and crash of battle are replaced by the tolling of bells and the ar of happy crowds, industry will be confronted with the question, "What now?" re you ready for that day?

Though our capacity is, at present, devoted to the winning of the war, we are ble to assist you at this time in the development and improvement of products for ost-war use. Avail yourself of the services of our technical staff. It may show ou how it is possible to improve the performance of your post-war products by aking advantage of the extraordinary properties of these vital Riverside alloys: hosphor Bronze, Nickel Silver and Beryllium Copper. To such a service we bring the ollective ability, experience and facilities of an organization which has specialized n the production of these engineering materials for many years.

Please send your inquiries to our main office at Riverside, N. J. or to our nearest ranch office.



RIVERSIDE

THE RIVERSIDE METAL COMPANY

Producers of the 3 Vital Alloys:

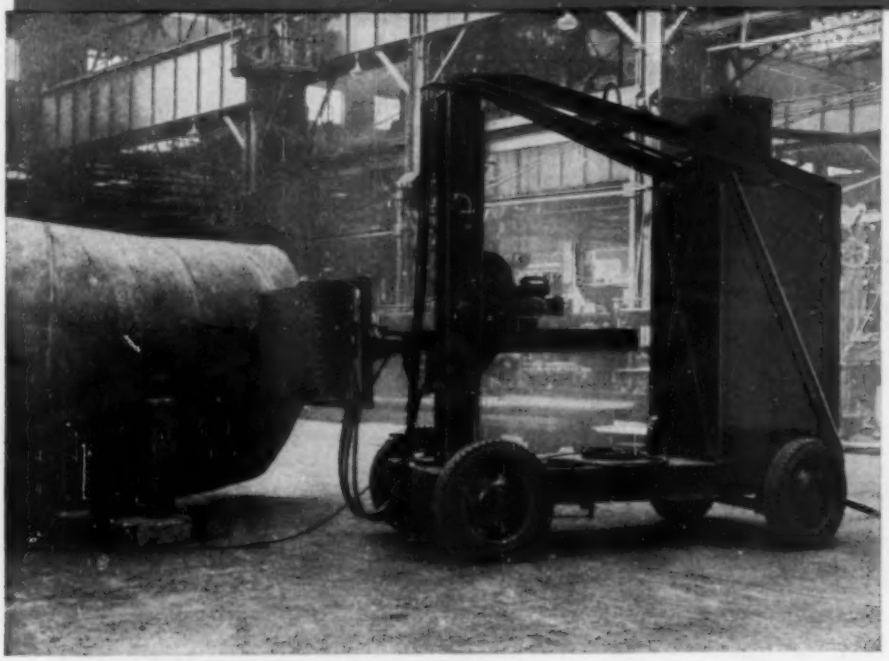
BERYLLIUM COPPER • PHOSPHOR BRONZE • NICKEL SILVER

Sheet Strip Wire Rod

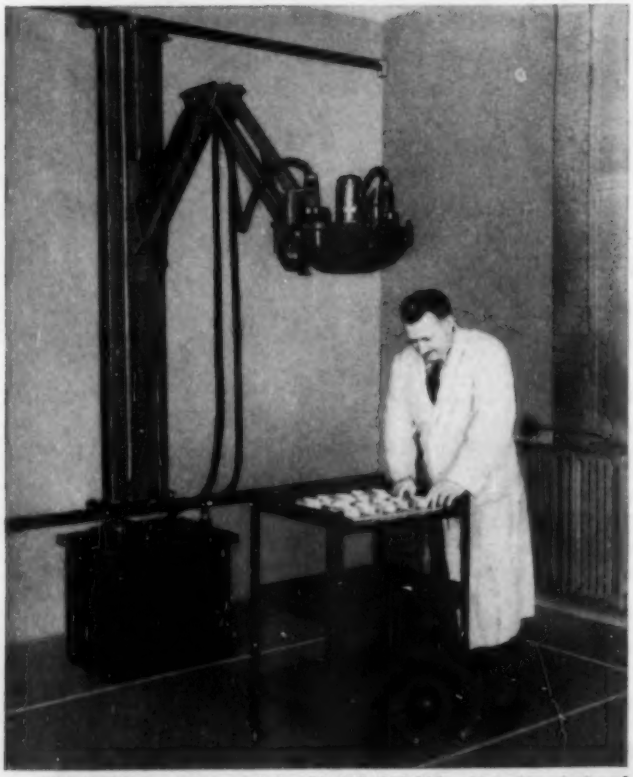
RIVERSIDE . . . Burlington County . . . NEW JERSEY

W YORK HARTFORD CLEVELAND CHICAGO

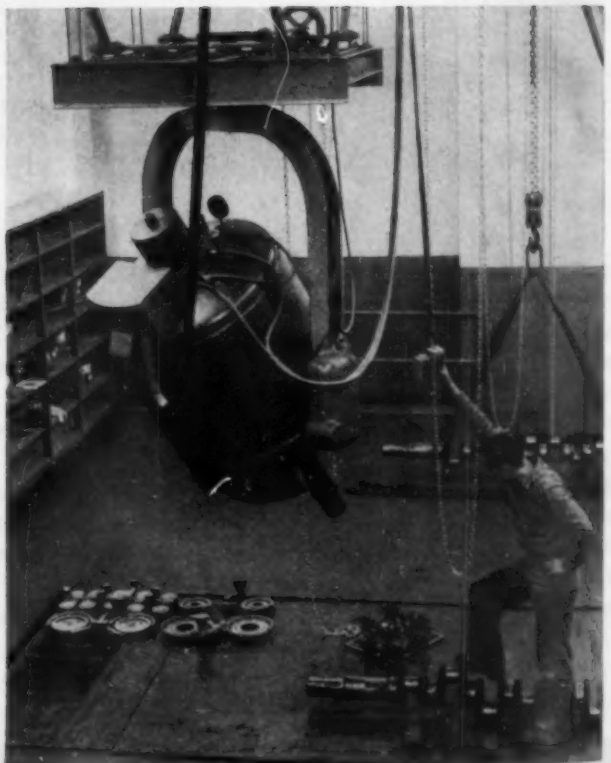
THERE'S A G-E X-RAY UNIT FO



In 1939, G-E X-Ray introduced this mobile jib crane truck mounting which provides an unusual degree of flexibility and permits easy, accurate positioning for practically all types of radiographic inspection. The tube head column can be rotated 360° about its vertical axis and has a radiographic area of 270° around the chassis. The travel range of the tube head is 6 feet vertical and 4 feet horizontal. This unit can be moved about the plant very easily by available man-power; for long hauls a tractor can be coupled to the unit and it can be moved to the job. This unit is available for use either with the G-E Model OX-200 (200,000-volt) or the G-E Model OX-250 (250,000-volt) Industrial X-Ray Units. Within their range, these x-ray units offer fast radiographic inspection of castings and weldments which cannot be conveniently moved to the x-ray inspection department.



In 1938, G-E X-Ray introduced the OX-140 (140,000-volt) unit — designed and built expressly to meet the low-voltage radiographic inspection needs of the light alloy casting industry. Shown here is the G-E Model S-57 wall-mounted tube stand which provides complete flexibility and wide useful radiographic area; transformer can be arranged for floor or ceiling mounting. The OX-140 mobile truck unit provides the same degree of flexibility and angulation available with the wall-mounted stand.



In 1941, G-E X-Ray introduced the 1,000,000-volt Industrial X-Ray Unit, shown here mounted on an overhead bridge crane which provides the complete flexibility necessary to facilitate fast radiographic inspection of large, heavy specimens. 5¼-inch welded plate can be radiographed in 10 minutes with the G-E million-volt unit as compared with the 7½-hour exposure formerly required to do the same job. The G-E 1,000 Kvp. unit does the job faster, and the end results are materially better and provide more diagnostic information.

OR EVERY INSPECTION PROBLEM

In 1942, G-E X-Ray introduced the Semi-Automatic Unit which provides rapid, accurate production-line x-ray examination of light alloy castings or metal assemblies.

For more than 25 years G-E Engineers have designed and manufactured x-ray diffraction equipment. The G-E XRD-1 Unit is the logical culmination of these years of experience and it has been accepted by chemists, engineers, and metallurgists as unparalleled for precision research.

HUNDREDS of high-powered G-E Industrial X-Ray Units are in daily use inspecting vital materials manufactured for the United Nations. With today's increased production schedules it is necessary to insure quality, save time and cut rejects to a minimum so that the flow of essential war materials will not be interrupted.

G-E Industrial X-Ray Units are designed from the drawing board on up for *industrial* use. They incorporate x-ray transformers and tubes, controls, and mountings especially designed for industrial service. Strength and durability are built into each unit to insure a maximum of uninterrupted service.

G-E X-Ray offers you the services of its corps of industrial x-ray engineers who have a background of more than 20 years' experience in applying x-ray examination in foundries, welding shops, aircraft factories, and other manufacturing establishments. They are aware of the production and inspection problems which are encountered in modern industrial practices. You can depend upon their recommendation as to which G-E Industrial X-Ray Unit will provide complete x-ray inspection in an *economical time.* And if x-ray inspection cannot be applied effectively and economically—they will be the first to tell you.

We are interested in a G-E Industrial X-Ray Unit to examine

- ☐ Aluminum-base castings.....inches thick.
- ☐ Zinc base castings.....inches thick.
- ☐ Copper base castings.....inches thick.
- ☐ Iron base castings.....inches thick.
- ☐ Weldments ☐ X-Ray Diffraction

Please have your engineer phone me for an appointment at my convenience.

Name _____

Title _____

Company _____

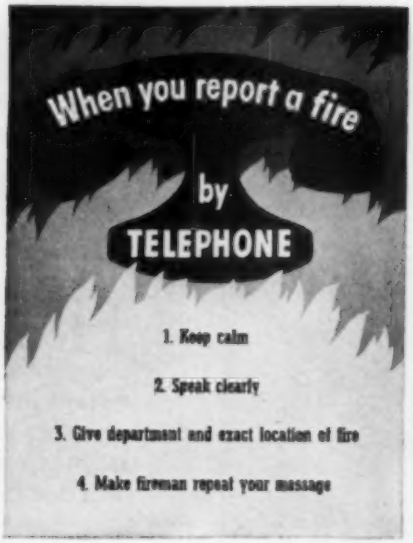
City _____ State _____

(Attach to your company letterhead)

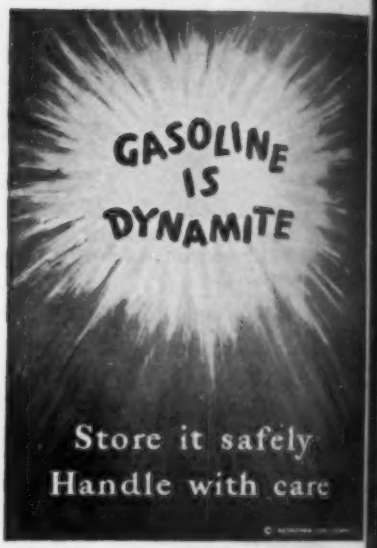
N112

Today's Your Day – A.S. Also Needs

GENERAL ELECTRIC
X-RAY CORPORATION
2012 JACKSON BLVD. CHICAGO (80) ILL., U.S.A.



fighting fires with



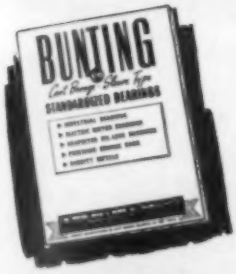
POSTERS

Bethlehem has long had an efficient fire-fighting organization. But war conditions multiply normal fire hazards. Thousands of new employees have come to work. Large additions have been made to existing facilities, and entire new departments set up. At the same time, war needs have intensified the pressure for production.

Since the start of the war emergency Bethlehem has redoubled its effort to keep down production loss due to fires. Much new equipment has been provided: extinguishers, alarm boxes, sprinkler systems, hose outlets and fire engines. And as plants grew, fire-fighting personnel was expanded, and given special training.

A poster campaign, of which a few representative samples are shown on this page, is one important detail of this program. Each poster registers in the employee's mind a single, specific point in fire-fighting or fire-prevention. Prominently displayed in steel plants, shipyards, fabricating shops, these posters are helping to maintain a favorable fire-loss record through the war years.

A fire on the production front can cost American lives on the battle-fronts. Even seemingly trivial fires have a grave cumulative effect. The aim is to prevent fires from occurring at all—and, if they do occur, to make them die young.



You can design to more readily available standard sizes and shapes and provide quick maintenance without sacrifice of bearing performance when you specify Bunting Bronze Standardized Bearings, completely machined and finished, ready for application in machine tools, electric motors, industrial machinery and equipment of all kinds. Available in many different sizes, Bunting Bronze Bars are machined I.D., O.D. and Ends. Solid Bars are centered. Ask your wholesaler. Write for catalog giving complete specification data. The Bunting Brass & Bronze Company, Toledo, Ohio. Warehouses in Principal Cities.

Bunting

BRONZE BUSHINGS • BEARINGS • PRECISION BRONZE BARS

PAGE *Welding* ELECTRODES

Then you know how important it is that the metal deposited in the weld shall equal the Stainless you are welding. **PAGE** took away all uncertainty in that regard when they, in cooperation with the largest manufacturers of Stainless Steel, produced a complete range of **PAGE-ALLEGHENY STAINLESS STEEL ELECTRODES**—a range so complete that from it you can select the exact electrode for your work.

★ ★ ★

Because Stainless Steel stands so high on the list of critical materials, it is more than ever necessary to see to it that the electrode you are able to get will give you the proper metal in the weld. And it becomes even more essential to see that you get electrodes of the proper diameter and that your men waste none of them.

PAGE STEEL AND WIRE DIVISION

Monessen, Pa., Atlanta, Chicago, Denver, Los Angeles, New York, Pittsburgh, San Francisco, Portland

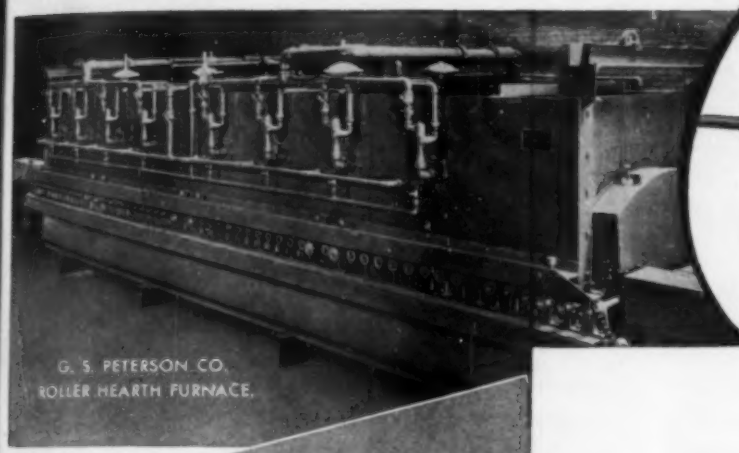
AMERICAN CHAIN & CABLE COMPANY, Inc.

BRIDGEPORT • CONNECTICUT

ESSENTIAL PRODUCTS . . . TRU-LAY Aircraft, Automotive, and Industrial Controls, TRU-LOC Aircraft Terminals, AMERICAN CABLE Wire Rope, TRU-STOP Brakes, AMERICAN Chain, WEED Tire Chains, ACCO Malleable Castings, CAMPBELL Cutting Machines, FORD Hoists, Trolleys, HAZARD Wire Rope, Yacht Rigging, MANLEY Auto Service Equipment, OWEN Springs, PAGE Fence, Shaped Wire, Welding Wire, READING-PRATT & CADY Valves, READING Electric Steel Castings, WRIGHT Hoists, Cranes, Presses . . . *In Business for Your Safety*

Save fuel... end worries

with a NORTH AMERICAN COMBUSTION SYSTEM



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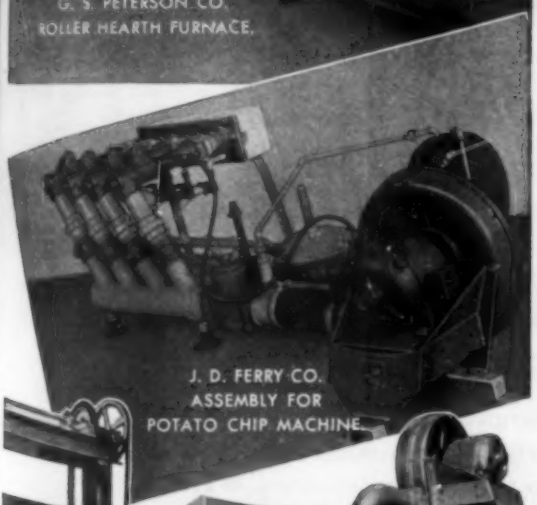
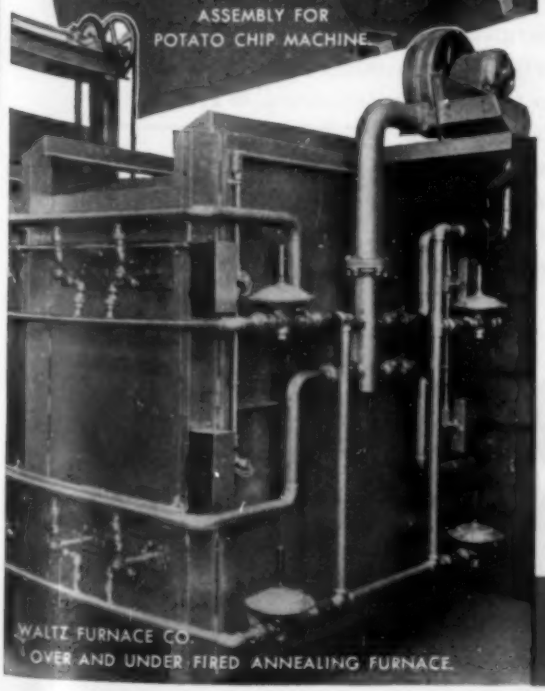
ROLLER HEARTH FURNACE.

LINDBERG ENGINEERING CO.
CYCLONE DRAW FURNACE



J. D. FERRY CO.
ASSEMBLY FOR
POTATO CHIP MACHINE.



WALTZ FURNACE CO.
OVER AND UNDER FIRED ANNEALING FURNACE.

Let us take the responsibility for the entire combustion system on your furnaces.

A NORTH AMERICAN factory-trained engineer is ready to help you select a complete combustion system consisting of the Turbo Blower, Proportioning Devices, Regulators, Control and Safety Valves, Pilots and Burners. But his job will not end there. Whether the fuel is gas, oil, or both, he will specify the correct pipe sizes needed to join these parts into an integrated combustion system which will operate at top efficiency and economy.

Specify NORTH AMERICAN today—all the way!

"NORTH AMERICAN for COMBUSTION"

THE NORTH AMERICAN MANUFACTURING COMPANY

MANUFACTURERS OF INDUSTRIAL FUEL BURNING EQUIPMENT FOR GAS OR OIL

BRANCH OFFICES with FIELD ENGINEERS in PRINCIPAL CITIES

CLEVELAND, OHIO

In the CLUTCHES of a WAR DRAGON

"WAR DRAGONS" like the one above—mechanized equipment on flat cars—are being rushed along the supply routes to our armed forces. Helping to get these "dragons" moving *fast* is Du Pont Carburizing Salt, used in quick, accurate case hardening of transmission clutch discs for tanks and trucks.

This is just one of many important war uses for Du Pont Carburizing Salt. But the experience of users shows many time-, labor- and cost-saving advantages:

1 Deep, high-carbon, low-nitrogen cases at from 1650° to 1750°F.—equivalent in all respects to those obtained by pack and gas hardening.

2 Accurate control of case depth and carbon content.

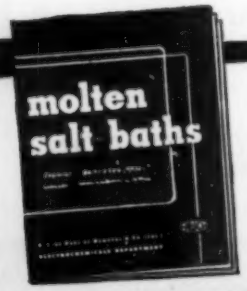
3 Carburization begins *immediately* upon immersion of work—there is no insulating layer to prevent heat penetration.

4 Baths are highly stable—only about 0.06% cyanide decomposition per hour at 1750°F.

5 Work may be quenched or slowly cooled directly from the bath without reheating.

Consult us today on how this and other Du Pont case-hardening and carburizing products can be applied to your specific job . . . no matter how big or how small. Skilled metallurgists in our laboratories and in the field will help you select the *right* materials to meet your requirements. Write: E. I. du Pont de Nemours & Co. (Inc.), Electrochemicals Department, Wilmington, Delaware.

BACK THE ATTACK WITH WAR BONDS



YEARS OF "KNOW HOW" IN THIS BOOK

More than 72 pages of practical material on heat treatment, fully illustrated. Ask for your copy.

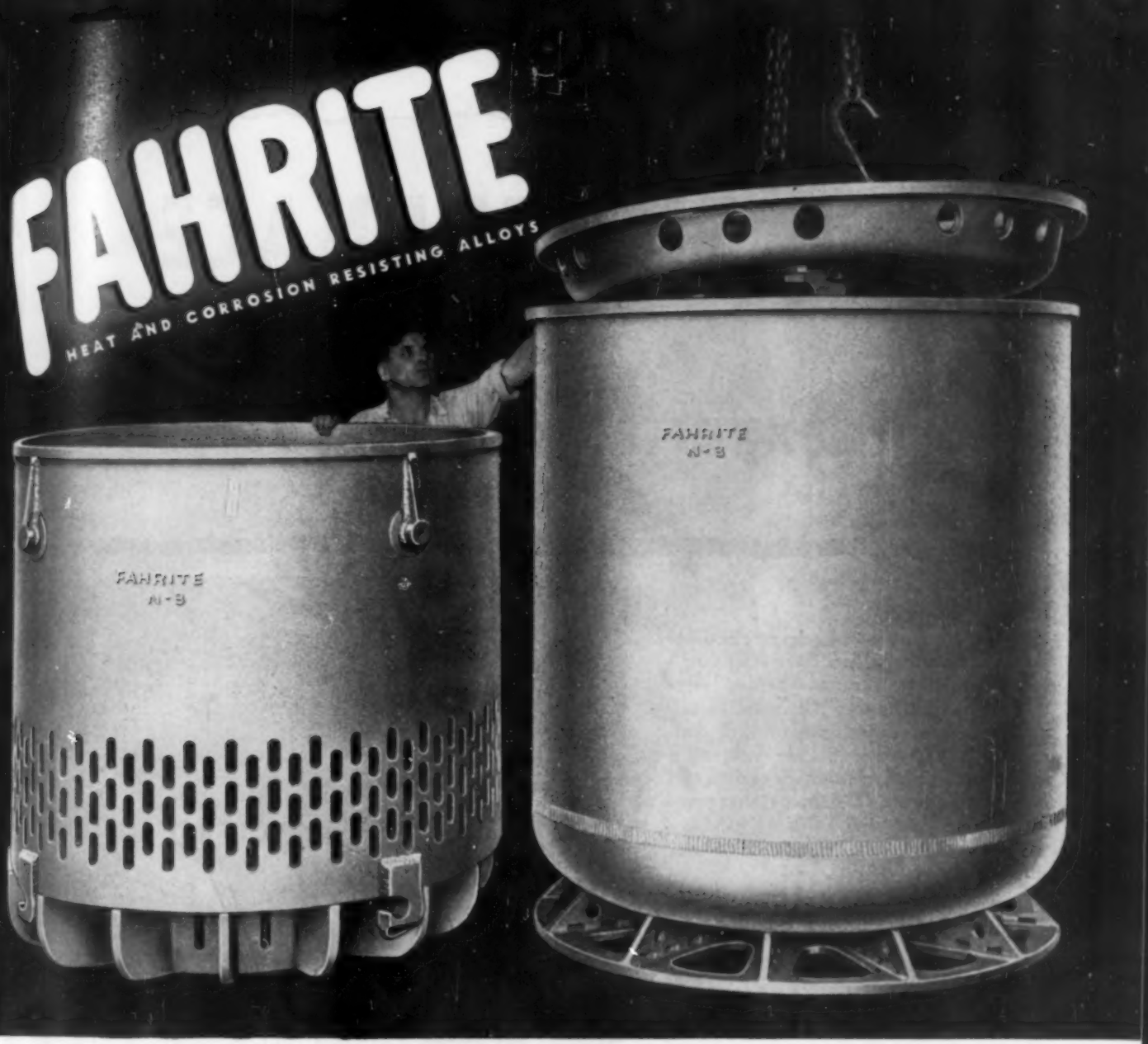
DU PONT

CYANIDES and SALTS for Steel Treating

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

FAHRITE

HEAT AND CORROSION RESISTING ALLOYS



CUSTOM designed and tailor-made, this retort of special-purpose FAHRITE was engineered and fabricated by us to do a specific heat treating job better. If the heat and corrosion resistance properties of FAHRITE . . . plus these facilities for specialized work . . . can aid your war production efforts, ask for details. Our engineers will help design FAHRITE parts.

THE OHIO STEEL FOUNDRY COMPANY

LIMA AND SPRINGFIELD, OHIO

ENGINEERS • FOUNDERS • MACHINISTS

FREE ENTERPRISE IS THE ONLY WAY TO CONSTANTLY HIGHER AMERICAN LIVING STANDARDS

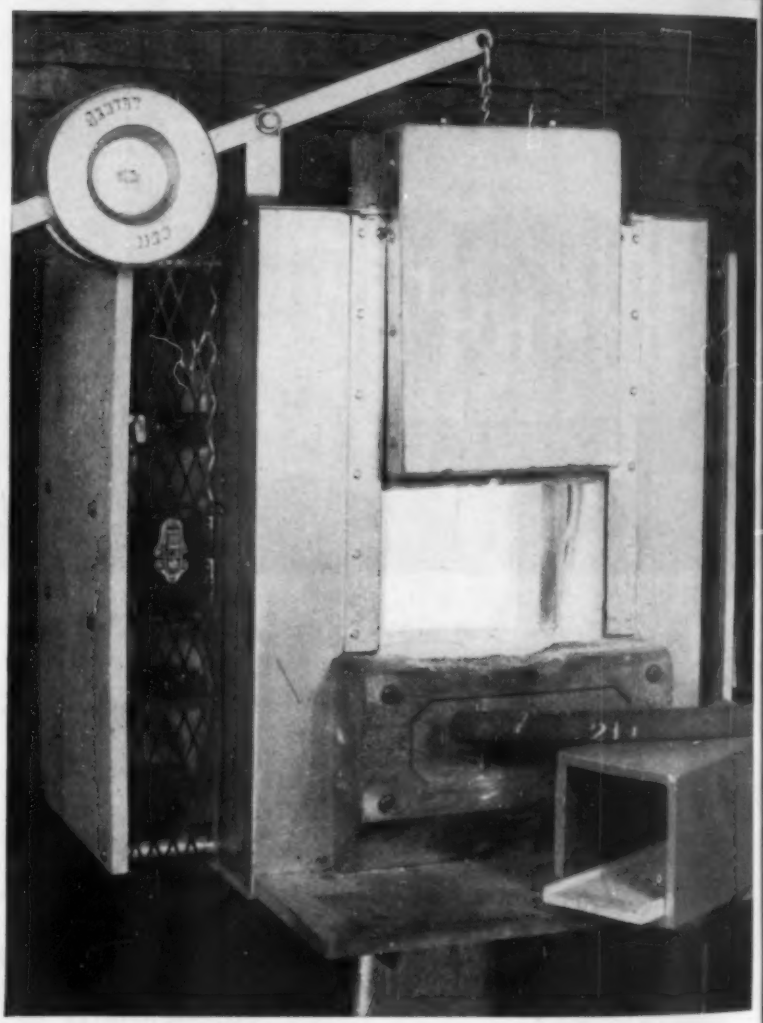
SENTRY FURNACE
for
inexperienced operators

IN one department of a large electrical manufacturer where these "Globar"-equipped high temperature "Sentry" electric furnaces using the "Diamond" block method of hardening are installed, eminently satisfactory results are reported in heat treating high speed, high carbon and high chrome steels. It is claimed that parts are heat treated to the desired hardness without carburization, decarburization or scale formation.

This method assures an oxygen free atmosphere in the furnace chamber, by the simple expedient of placing the parts to be heat treated on refractory trays inside a muffle of carbonaceous material. This in turn is fitted closely into a bonded silicon carbide muffle heated by "Globar" Electric Heating Elements placed horizontally above and below.

Among the other advantages inherent in this furnace are (1) the short time required to bring it up to full heat . . . (for small furnaces, less than an hour), (2) accurate temperature control, (3) absence of cold zones, (4) cleanliness, and (5) low operating costs.

Our engineers will be glad to consult with you about your industrial heating problems. Manufacturers of vital war materials can be sure of reasonably prompt deliveries of "Globar" products.



"Sentry" furnace showing "Globar" heating element and "Diamond" block muffle in which steel is heated.

Globar Division

THE CARBORUNDUM COMPANY • NIAGARA FALLS, N. Y.

REG. U. S. PAT. OFF.

MANUFACTURERS OF GRINDING WHEELS, COATED ABRASIVES, SUPER REFRACTORIES, HEATING ELEMENTS

(Carborundum and Globar are registered trade-marks of and indicate manufacture by The Carborundum Company)

BOTTLENECKS

DAMN THE TORPEDOES

FULL SPEED AHEAD!

Making only Mounted Wheels and small Grinding Wheels—maintaining highest quality in spite of large quantities and rush orders—shipping them promptly. *This is our job, our battlefield.*

With full WPB approval, we stopped making all large size grinding wheels and fixed our sights on wheels *3" in diameter and under.*

We worked all around the clock, 24 hours a day, and in a short time were able to fill orders on time—And, our central location cuts time in transit. Today, there is no waiting. With the Army-Navy E at our masthead, we are going full speed ahead.

AMERICA'S HEADQUARTERS FOR

MOUNTED WHEELS

SMALL GRINDING WHEELS

Half a century of specialization has established our reputation as the Small Wheel People of the Abrasive Industry. You can bank on us.

TEST WHEEL FREE—To get acquainted with Chicago Wheels, let us send one postpaid. Tell us size wheel and material you wish to grind.

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MP-11

Send Catalog. Interested in:

☐ Mounted Wheels ☐ Grinding Wheels ☐ Send Test Wheel. Size_____

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IN 194..? M-H/Brown Electronic Recording and Control Instruments will usher in a new era in peacetime production.

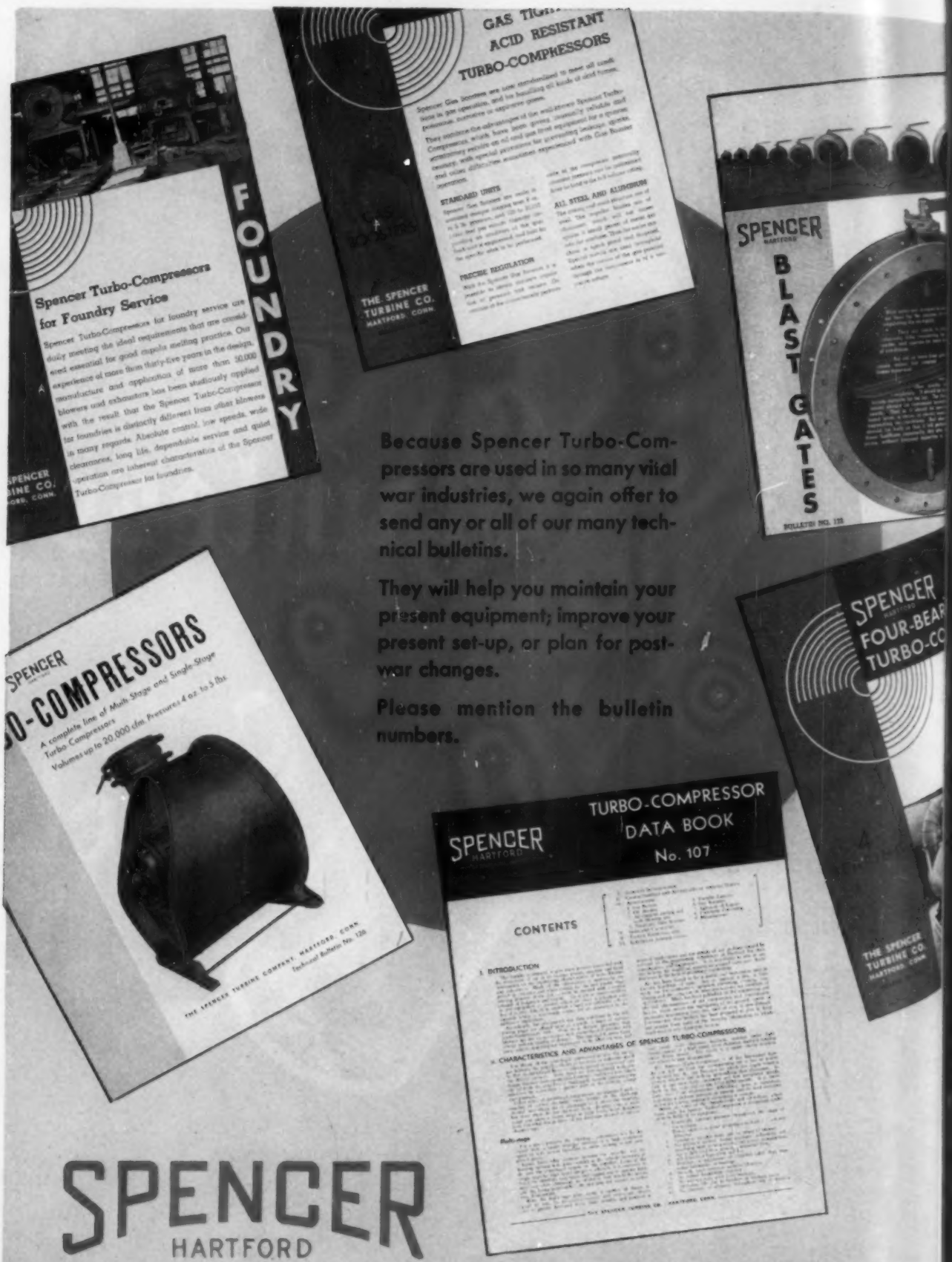
In the manufacture of chemicals, petroleum products, steels, textiles, rubber, ceramics, paper, foods — and other products, M-H/Brown Electronic Instruments will provide a new conception of greater precision in measuring and controlling industrial processes.

We are proud of the M-H/Brown background of over 100 years experience in instrument engineering which *pioneered electronic instrumentation.* Today these instruments are producing the tools of war. When peace comes they will be available to industry. *M-H/Brown Electrons are coming.*

The Brown Instrument Company, 4503 Wayne Ave., Philadelphia, Pennsylvania, a division of Minneapolis-Honeywell Regulator Company, Minneapolis, Minnesota. Offices in all principal cities. 119 Peter Street, Toronto, Canada — Wadsworth Road, Perivale, Middlesex, England — Nybrokajen 7, Stockholm, Sweden.

Instruments by **BROWN** *and Controls by*

MINNEAPOLIS-HONEYWELL



SPENCER
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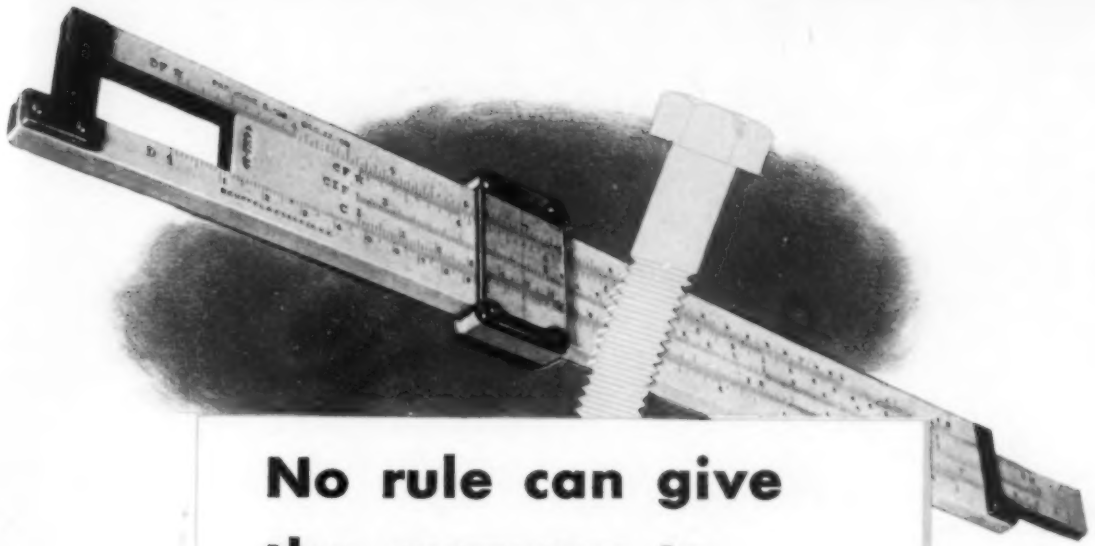
TURBO-COMPRESSOR BULLETINS

THE SPENCER TURBINE COMPANY • HARTFORD, CONNECTICUT



No rule can give the answers to ALL metal problems

A HANDY device, the slide rule. Knowing the physical properties of a metal you can find the strength of a bolt, for instance, just like that. But there are *other* things about a bolt material you also need to know: Can it upset cold—or does it hot work easily? Can it be roll threaded? Does it machine readily? Is it rustproof? Will it resist vibration? Is it corrosion resistant—or will outdoor exposure create a constant threat of failure, possibly involving costly equipment?

EVERDUR

An Engineered Metal—for Engineers

A slide rule cannot give you the answers, but there is a metal in the Copper-Silicon Alloy group (Everdur*) that will. In the electrical field alone, millions of Everdur bolts and other items of pole line hardware have been giving dependable service for years in highly unfavorable locations. And for good reason! . . . Everdur was *developed* for structural and engineering uses requiring a workable and weldable metal with the tensile strength of mild steel and the corrosion resistance of copper.

SEMI-FINISHED METAL PRODUCTS

Save *your* time—*your* equipment

Other products of The American Brass Company have provided the answer to production of complicated parts of unusual design. Special Extruded or Drawn Shapes in pinion, cam, and many other irregular sections—in copper and nearly all of its alloys, in long mill lengths—suitable for screw machine use or ready for cutting up into assembly parts with little or no machining • Consider also Anaconda Hot Pressed Parts—gas, air and water tight with twice the strength of sand castings—uniform, accurate in dimension, and a wide range of copper alloys from which to choose • Or Anaconda Pressure Die Castings with their adaptability to intricate coring . . . with all the advantages of other types of die castings—*plus* higher strength, greater hardness and toughness, higher resistance to impact and, being copper alloys, possessing freedom from rust and a high degree of corrosion resistance.

ANACONDA
from mine to consumer

Anaconda Copper & Copper Alloys

BRASS, BRONZE, NICKEL SILVER

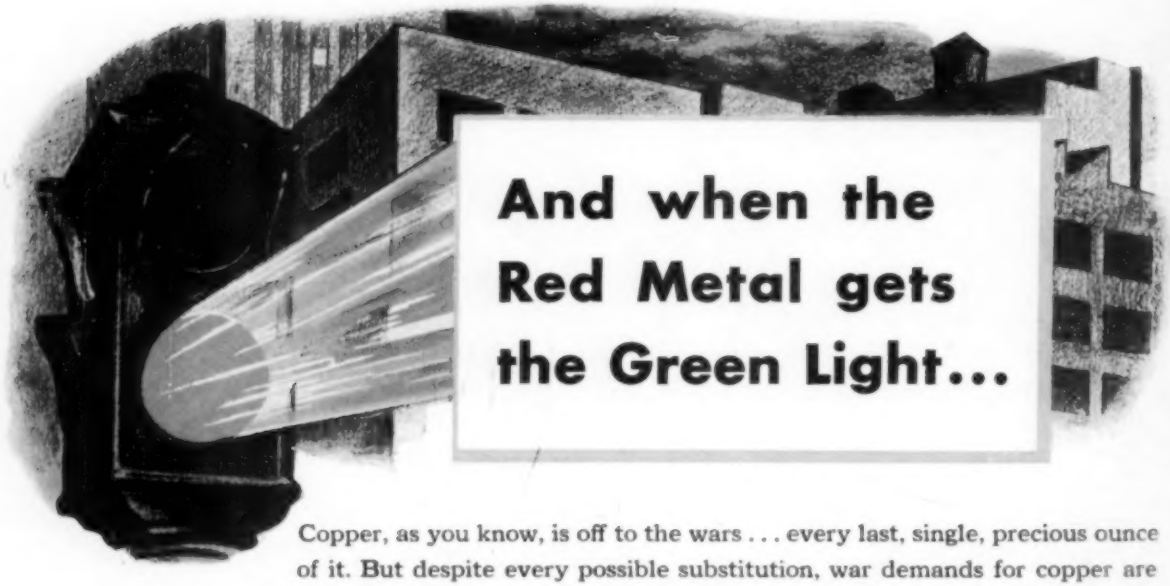
Old Standbys—for Old and New Products

Answers to other metal problems are often found in Brass, Bronze or Nickel Silver. One of these strong, ductile, workable copper alloys, in suitable composition, with temper and grain size adjusted to the need, is more than likely to give the utmost value for operations such as spinning, stamping, cupping, forming, deep drawing, machining—or for whatever metal-working operation your product calls. These time-tried metals offer other economies; in longer life for dies and cutting tools; in greater uniformity of parts; in brazed, soldered or welded assemblies. And, lest you forget, products made of Copper Alloys possess Copper's immunity to rust and provide good resistance to corrosion.

FINDING THE ANSWER . . .

Experience? Research? Special Alloys?

Naturally we don't know all the answers to metal problems, but with the accumulated experience of more than a hundred years we have had the opportunity to work out many of them. Frequently a solution has been found in an alloy with special characteristics, such as Avialite*, Tobin* Bronze, or Beryllium Copper. Our Research Department has produced and tested many special copper-base alloys, most of which are now in common use for special types of service. We will be glad to discuss with you war production metal problems which you may consider especially difficult.



And when the Red Metal gets the Green Light...

Copper, as you know, is off to the wars . . . every last, single, precious ounce of it. But despite every possible substitution, war demands for copper are greater than its vastly increased production. The properties which have made this metal and its alloys so essential for our tools of war—high electrical and thermal conductivity, resistance to corrosion, strength, workability and durability—are the same properties which make these metals indispensable to industry.

So when, with peace, Copper gets the green light, it will resume its role as the "metal of progress"—contributing its many desirable properties to the development and construction of countless improvements in the art of living, in the fields of science, engineering and manufacture.

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ANACONDA

THE AMERICAN BRASS COMPANY

General Offices: Waterbury 88, Connecticut • Subsidiary of Anaconda Copper Mining Company

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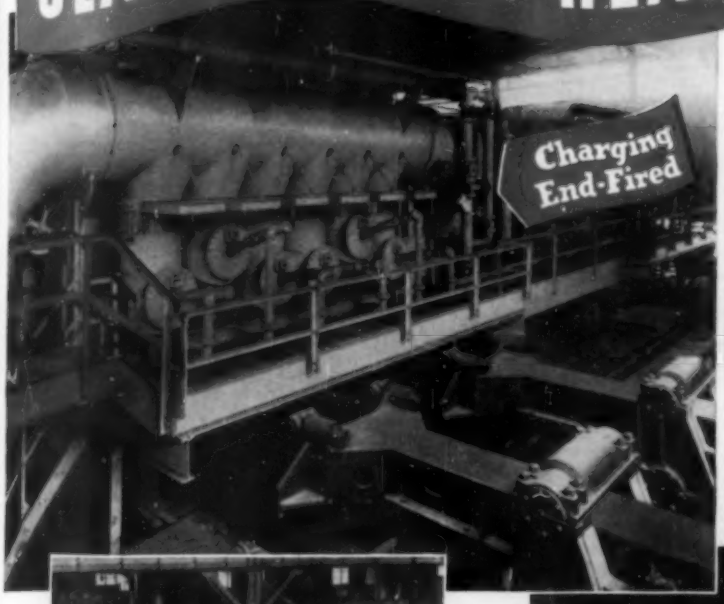
Anaconda Copper & Copper Alloys

AMCO

Continuous Recuperative

SLAB AND BILLET HEATING FURNACES



AMCO Continuous Slab Heating Furnaces and AMCO Pit Furnaces were selected to serve a large, new American Plate Mill

Amco Also Builds Open Hearth, Recuperative Side-Door Heating, and Heavy-Duty Forge Furnaces

The **AMSLER-MORTON** *Company*

FULTON BUILDING · PITTSBURGH, PA.

. . . No matter whether your peacetime Heat Treating needs will be . . GREAT

FLINN & DREFFEIN WILL BE ABLE TO SERVE YOU BETTER

The increased facilities and engineering knowledge acquired in this emergency will enable Flinn and Dreffein to serve your peacetime Heat Treating needs better. If your requirements will be tons per hour or pounds per hour, Flinn and Dreffein engineers can provide you with the proper unit or units to accomplish the job faster, better, and at less cost. A recent example of Flinn and Dreffein ingenuity is a heat treating giant capable of thirty tons (60,000 pounds) of 8" to 20" pipe *per hour!*

or

Whether your specific problem requires new or converted equipment, Flinn and Dreffein can provide you with the proper dependable solution.

Write today!

Associated Company
WEAN ENGINEERING COMPANY, INC.
WARREN, OHIO

...are Deepfreeze Chilling Machines Used for the Cold Treatment of Metals?

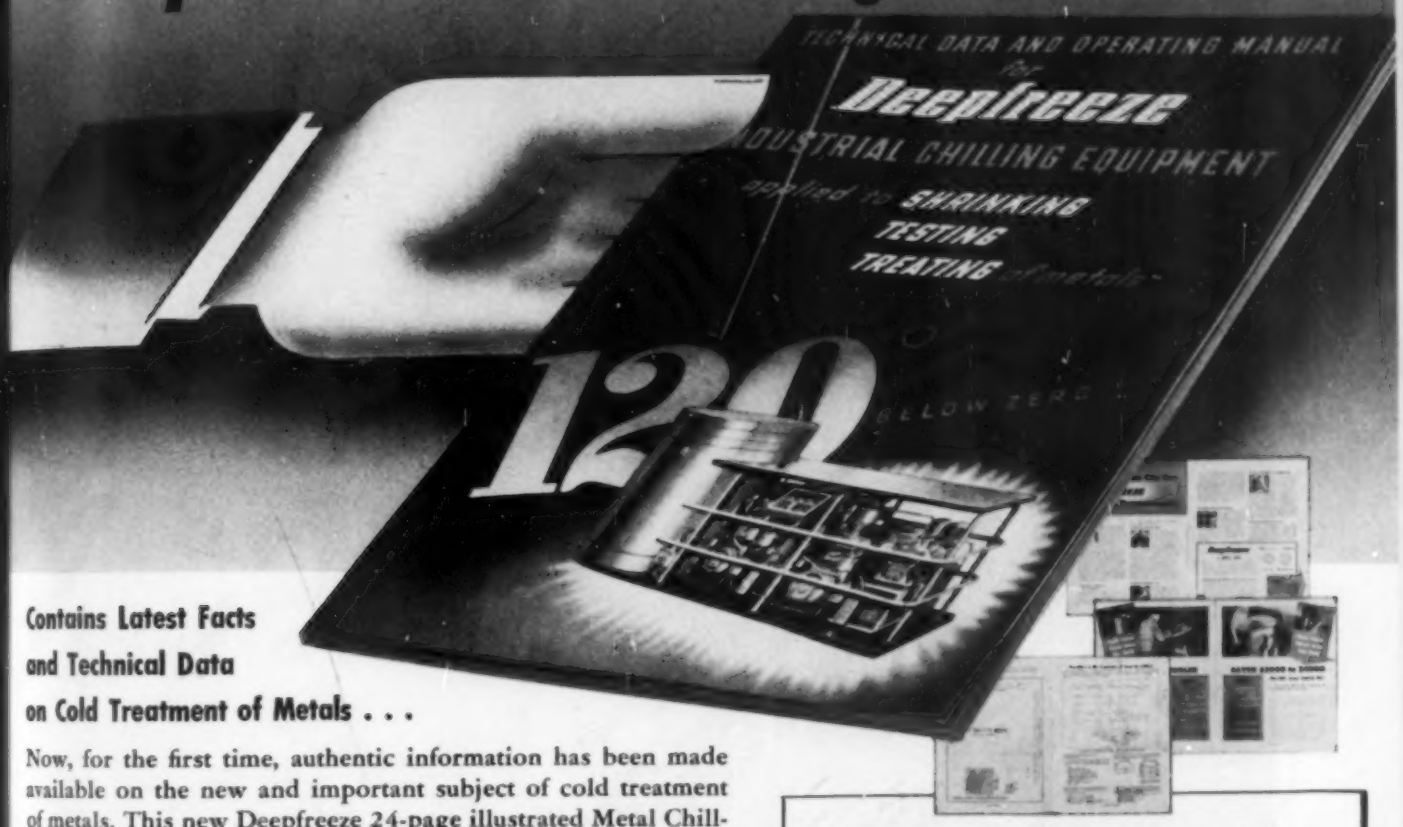
How Can You Use Sub-Zero Temperatures in Your Plant?

What are the Latest Facts About the Use of Sub-Zero Temperatures?

Get the answers in this new

FREE

Deepfreeze Metal Chilling Data Book



Contains Latest Facts and Technical Data on Cold Treatment of Metals . . .

Now, for the first time, authentic information has been made available on the new and important subject of cold treatment of metals. This new Deepfreeze 24-page illustrated Metal Chilling Data Book contains the latest information and technical data on the application of Deepfreeze Industrial Chilling Machines.

In this handy working guide on the use of industry's newest production tool you can learn how to use sub-zero temperatures for the shrinking, testing, hardening and stabilization of metals in your plant.

Get Your Free Copy Today—Every executive concerned with the "conditioning" of metals should have a copy of this new book. Whether you have a problem in metal shrinking, treating or testing, or whether you are not sure if Deepfreeze sub-zero temperatures can be applied to your manufacturing, this new book can be of value to you. A free copy can be obtained by writing Deepfreeze, North Chicago, Illinois. Write today for as many copies as you need.

24 Pages of Technical Data, Tables, and Other Valuable Facts

These are just a few of the things you will find out in this book about the cold treatment of metals:

I—How cold treatment is used to harden and stabilize high speed, moly-type and other steels.

II—How to calculate the rate of production obtained in reducing the temperature of a quantity of work to a specified temperature.

III—How one manufacturer saved $3,000 to $4,000 per month over liquid air in a shrink-fit assembly.

IV—How chilling in a Deepfreeze prevents expansion and growth of precision gauges.

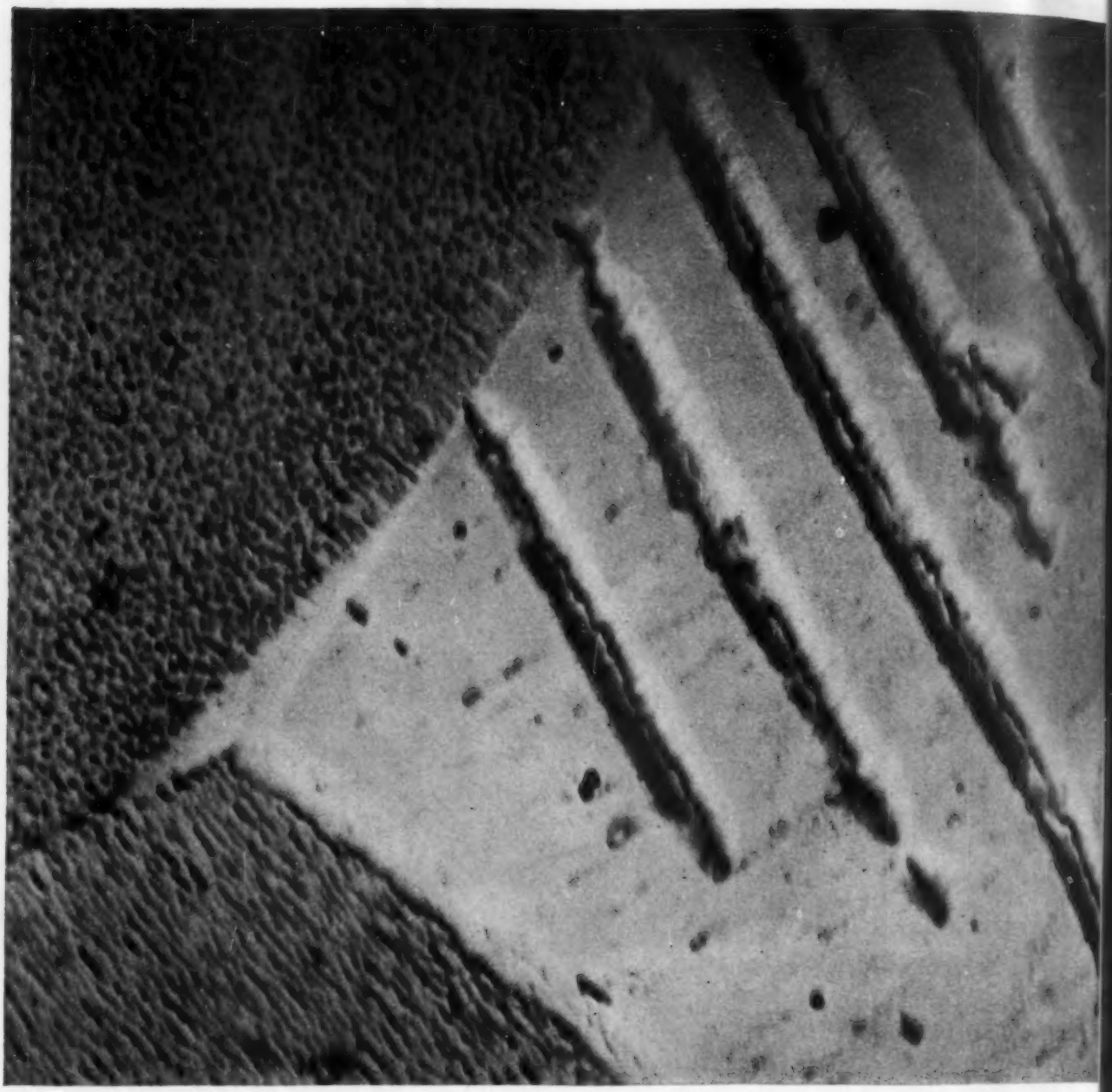
Deepfreeze

2325 DAVIS STREET
NORTH CHICAGO, ILLINOIS

TRADE MARK DEEPFREEZE REGISTERED UNITED STATES PATENT OFFICE

...trial Chilling Equipment for Shrinking, Testing, Hardening and Stabilizing Metals

Division of Motor Products Corporation, Detroit, Michigan



Few Metallurgists Ever Saw Stainless Steel Like This

THIS picture, reproduced from a micrograph made with the famous RCA Electron Microscope, shows stainless steel magnified 16,500 times! Observe the sharply defined grain boundaries and twinning — disclosed by the extraordinary resolving power that is so characteristic of the RCA Electron Microscope, even at very high magnifications. In addition to showing the surface appearance in great detail, the RCA Electron Microscope facilitates diffraction studies which indicate crystalline structures and chemical components of any metal or alloy. Here, indeed, is an instrument of the utmost importance to metallurgists—as an aid to research, and also as an unrivaled means of checking metallurgical processes and results in practical *production*. The RCA Electron Microscope is already used in this manner by some of the largest metallurgical plants in the United States. Please address inquiries to *Engineering Products Department*, RADIO CORPORATION OF AMERICA, *Camden, New Jersey*.

★ *BUY MORE WAR BONDS* ★

RCA ELECTRON MICROSCOPE

RCA Victor Division • RADIO CORPORATION OF AMERICA • Camden, N. J.

They needed

great strength—light weight—ductility for cold forming

They got all 3-plus

IN **N-A-X** X-9120

The Signal Corps Cable Reel, illustrated above, is an interesting example of the ingenuity of Noblitt-Sparks Industries, Inc., of Columbus, Indiana.

Slammed and bumped, rushed into action at frenzied speed, these reels have to be light in weight and easy to carry—and yet have the rugged strength and stamina to stand up under the extremely hard usage of modern warfare.

It is significant, therefore, that for the manufacture of these reels, Noblitt-Sparks selected N-A-X X-9120 made by Great Lakes. This steel not only provides a product of great strength and light weight, but also assures high impact resistance at both normal and extremely low temperatures. And today, when fighting equipment is used in all climates—from arctic cold to equatorial heat—this latter characteristic is of special importance.

Another advantage of N-A-X X-9120 is its ductility which permits easy cold forming and thus helps to speed production.

On every fighting front—in practically every type of war equipment—you will find steel by Great Lakes. This widespread service-testing should be a helpful guide in buying steel for *your* requirements.

GREAT LAKES STEEL CORPORATION

DETROIT, MICHIGAN

Sales Offices in Principal Cities

Division of **NATIONAL STEEL CORPORATION** *Executive Offices, Pittsburgh, Pa.*

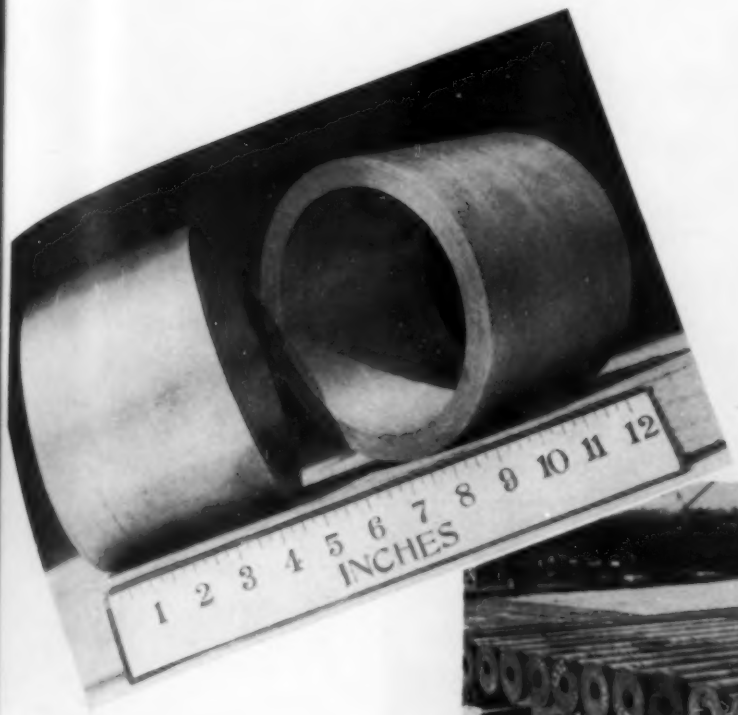
DUCTILITY

ITS IMMEDIATELY FINER GRAIN MAKES ALL THE DIFFERENCE

STRENGTH

ACIPCO STEEL – *Centrifugally Cast* TUBES

TOP: High nickel-chrome heat resisting alloy steel retorts centrifugally cast in 16-foot lengths. Left: Rudder stock fabricated from centrifugally cast steel tubing welded to statically cast flange section.



LEFT—BEARING BACKS:
Produced from 16-foot length Type 1015 steel tubes.

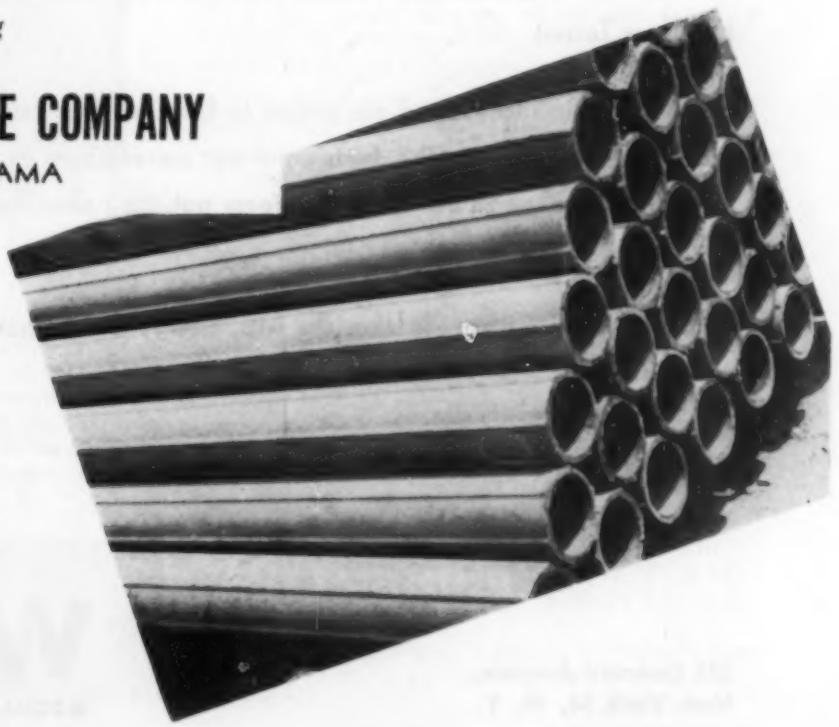
RIGHT—SHAFTING FOR SHIPS:
Cast in 16-foot lengths

Acipco centrifugally cast steel tubing and parts, produced from electric furnace steel, are being supplied in ever increasing quantities under rigid chemical and physical specifications. Manufacturing capacity is available for further production under suitable priorities. We solicit your inquiries.

Write for Catalog

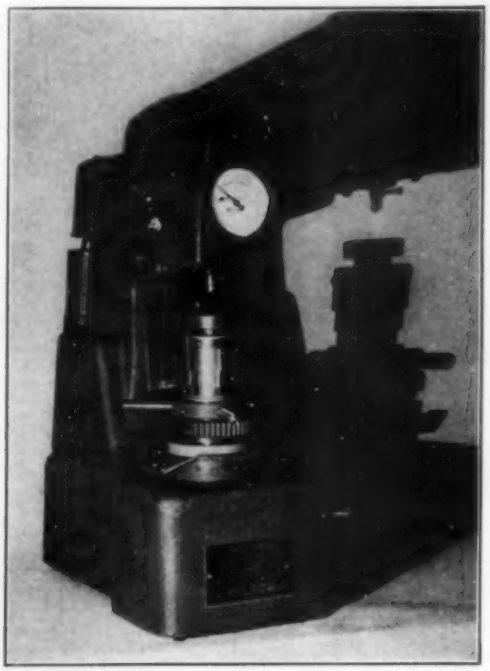
AMERICAN CAST IRON PIPE COMPANY

BIRMINGHAM 2, ALABAMA



RIGHT—FLUTED TUBES:
Cast in 16-foot lengths, later to be fabricated into small electric motor stators.

"ROCKWELL"
HARDNESS TESTER



Shipment of normal type hand-operated machines can be made in less than a week.

We did not wait for less busy times to launch greatly improved models of the "ROCKWELL" Hardness Tester.

It was a hard job to expand our output to five times normal and still make radical improvements in design. It was the decision of our management to do it, but we wish to acknowledge that all departments in our business put their shoulders to the wheel and pushed it across.

A plan is only a plan. It takes the wits, energy and enthusiasm of real people to make a plan a reality.

383 Concord Avenue,
New York 54, N. Y.

WILSON
MECHANICAL INSTRUMENT CO., INC.

HARDENING TIME CUT

FROM 6 HOURS TO 3.1 SECONDS!

HOW would you surface-harden the teeth of this two-inch-diameter gear? Pack it in carbon and heat it in a furnace *for three to six hours?*

That's one way.

But you can do the same job in *a little more than 3 seconds*—and do it better, more uniformly, with a G-E electronic heater. And relatively little experience is needed—the operator just places the part within the heater coil and presses a button. The surface is heated and quenched in 3.1 seconds!

These electronic heaters have thousands of varied applications. Practically any metal — steel, copper, aluminum, magnesium, brass, nickel, etc. — can be heated inductively. With these heaters you can heat for annealing, brazing, soldering, or forging in a very short time and with great accuracy.

Both the heated area and the depth of heating can be controlled within fractions of an inch, and both the heating and the quenching cycles are entirely automatic. Each part receives *exactly* the same treatment.

You should have all the facts on how G-E electronic heaters can help speed up your production. Simply contact the nearest G-E office, or write to General Electric Company, Schenectady, N. Y.

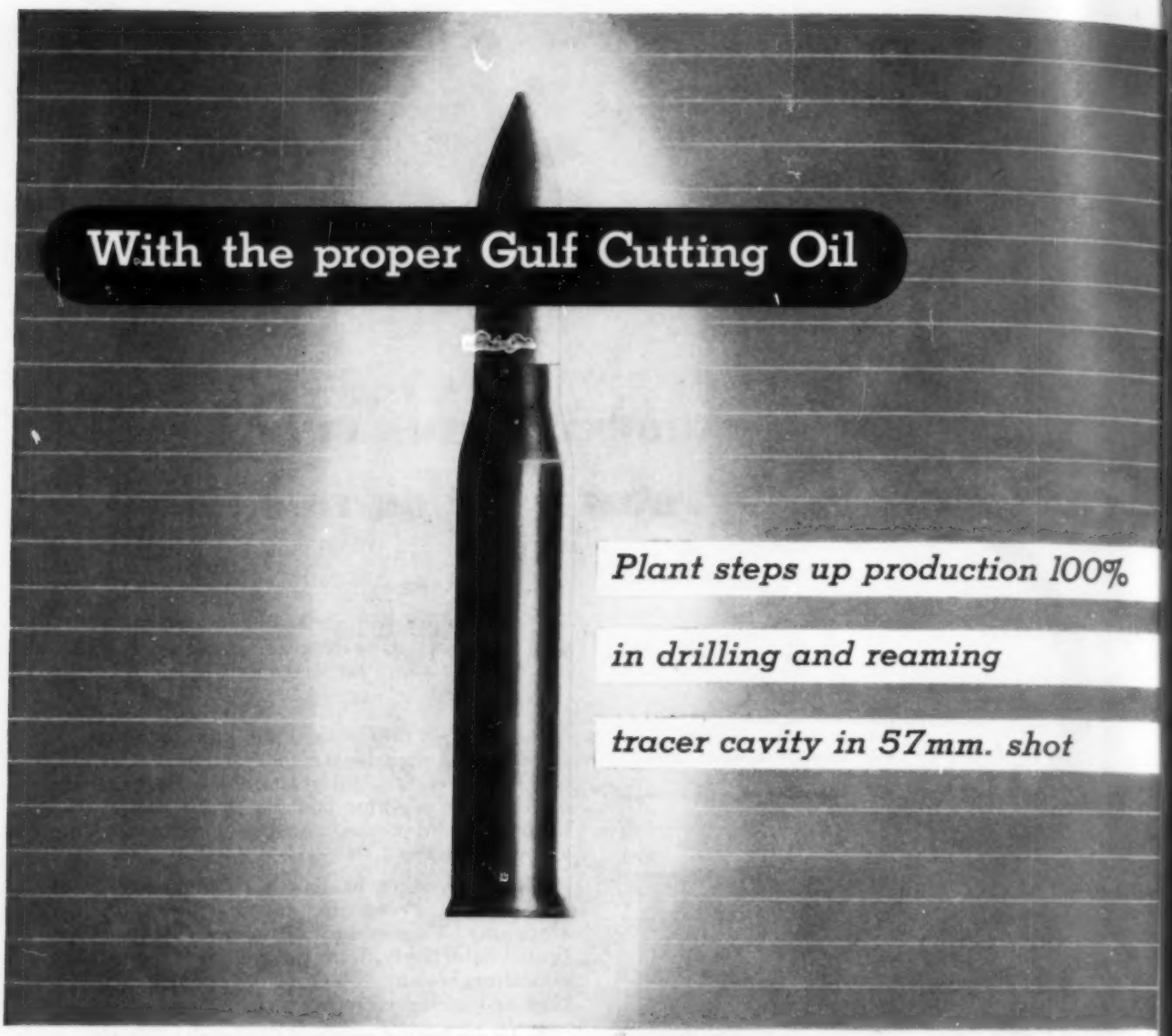
G-E electronic heaters are manufactured in two standard sizes with conservative output ratings of 5 kw and 15 kw. Larger sizes can be furnished to meet requirements.

● *Electronic heating is a new and powerful tool to help speed American war production. Like most new tools, it can easily be misapplied. The recommendations of G-E Industrial Heating Specialists are based on the experience gained with more than two hundred installations of electronic heaters plus a quarter century of experience in the development, manufacture, and application of electric heating equipment of all types.*

GENERAL ELECTRIC

ELECTRONIC HEATERS

The best investment in the world is in this country's future —
BUY WAR BONDS



Tool life greatly increased — finish substantially improved - - -

Another war plant steps up production through improved machine tool performance—thanks to the proper Gulf Cutting Oil, as recommended by a Gulf Service Engineer.

THE PROBLEM: Drilling and reaming the tracer cavity in 57 mm. armor-piercing shot, using soluble oil. Getting over 50% rejections, tool life 200 pieces. Rejections extremely costly, since these were final machining operations.

THE SOLUTION: Proper Gulf Cutting Oil put in service. No other changes in machining practice.

RESULT: Rejections entirely eliminated, representing a 100% increase in production, tool life increased 1,000%, finish substantially improved.

It will pay you to investigate Gulf Cutting Oils—call in a Gulf Service Engineer now and ask him how they can help *you* improve finish and increase production and tool life. For your copy of the booklet on Gulf Cutting Oils—which includes a helpful 45-page machining guide—send the coupon below.

GULF OIL CORPORATION · GULF REFINING COMPANY

Tools are weapons
Treat 'em right!

GULF INDUSTRIAL LUBRICATION

Gulf Oil Corporation—Gulf Refining Company MP
3800 Gulf Building, Pittsburgh, Pa.

Please send me, without obligation, a copy of the new revised booklet, "Gulf Cutting Oils," which includes a helpful Machining Guide.

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Company.....

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In heat treating aluminum alloy parts "L" Nickel resists corrosion and oxidation by Sodium Nitrate at 980° F.

Fused sodium nitrate baths . . . used for heat treating duralumin fighter plane parts rapidly, uniformly and without oxidation . . . are heated to and held at 980°F. continuously by immersion-type electric heaters.

The sheathing of the heaters, immersed in the molten sodium nitrate, encounters highly corrosive action.

Carbon-free "L" Nickel resists corrosion and embrittlement by these molten salts. It also retains good mechanical properties at operative temperatures.

You may have a problem that is entirely different. But whatever special characteristics you need in a metal, you are invited to call upon INCO's Technical Service for information and data. You, too, may find that an INCO Nickel Alloy will solve your problem.

---

*The details of this use of carbon-free "L" Nickel are published in the belief that they will be of interest and value to engineers and designers working on similar problems, though the use of "L" Nickel today is restricted to approved applications.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 WALL STREET NEW YORK 5, N. Y.

Close-up of "L" Nickel-sheathed immersion heaters that hold sodium-nitrate at 980° F. for use in heat-treating duralumin parts for fighting planes.

★ ★ ★ ★ **INCO NICKEL ALLOYS** ★ ★ ★ ★

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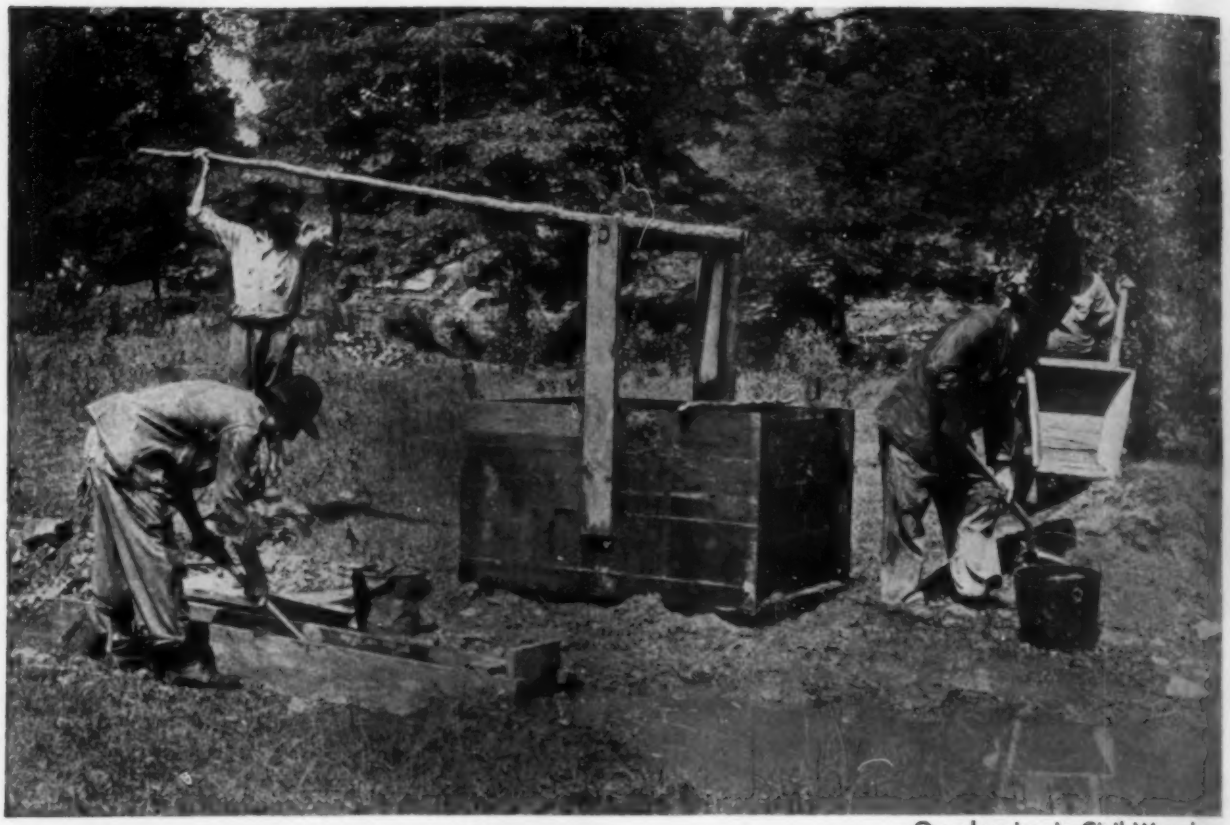

Ore dressing in Civil War days
Bureau of Mines Photo

MANPOWER

The greatest problem confronting industry today is manpower. A year ago, even six months ago, the problem was material—in the non-ferrous metals field: aluminum, copper, zinc, lead, etc. In October, High Grade zinc was placed in Group II of Material Substitutions, indicating supplies "sufficient to meet war demands plus essential industrial demands under existing administrative control."

In order to produce the greatest quantity of war materiel today, parts must be manfactured with manpower economy; die-castings must be used instead of machined parts. England faced the manpower shortage long ago, and took up some of the slack by replacing machined parts and assemblies with die-castings.

Not only in war materiel but in the production of office machinery and other essential civilian products, engineers and designers should be considering the more extensive use of die-castings.

Follow the advice of the War Production Board as given in the Materials Substitutions and Supply List issued October 1, 1943: "Due to manpower shortages greater emphasis should be placed on the use of materials best suited to low unit labor processes such as stamping, die moulding and die casting, automatic screw machines, etc."

Die casting is the process—Zinc the material.

ST. JOSEPH LEAD COMPANY

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Lead	*Zinc Oxide*	*Antimony*
Zinc	*Antimonial Lead*	*Cadmium*

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SIMPLIFY QUALITY CONTROL

with easy-to-analyze x-ray inspection

Quality control of castings and weldments is easy, fast and absolute with x-ray inspection.

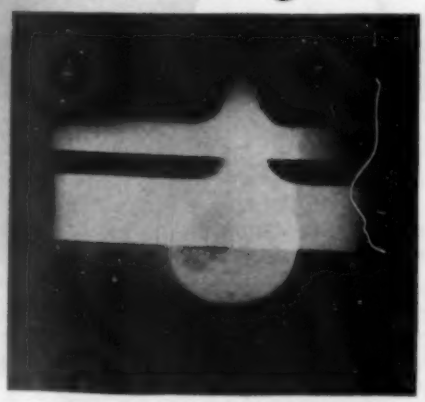
For example, suppose you have a casting that must be perfected before large scale pourings are practical. All you have to do to perfect quality is make small test casts—x-ray them—and you have an easy-to-analyze picture that shows up such variables as temperature of pour, location of gates and risers, ramming and shrinking.

Once perfected, an occasional x-ray is all that is necessary to maintain quality control—for there is no need for routine examination of every piece. Workmen learn quickly and pictorially the advantages and disadvantages of each modification in metal working procedures. And you make each test of quality absolutely —nondestructively.

Above all, you have pictorial proof for your customers that your products meet their established standards. No arguments—no renegotiations—no excuses.

X-ray is at work on hundreds of war jobs—saving machine and man-hours, conserving critical materials, speeding production, controlling quality and helping train workers. For more information, write for B-3159. It's a simplified booklet that shows you how and where x-ray can be used in industry. J-02024

LOOK INSIDE WITH X-RAY



This radiograph shows a blowhole in an aircraft casting . . . a typical example of how x-ray reveals subsurface defects.

Westinghouse

PLANTS IN 25 CITIES... OFFICES EVERYWHERE

INDUSTRIAL X-RAY

FUNDAMENTALS OF CIVILISATION

No. 4 SHELTER

To possess a habitation is the common instinct of every living creature. Nature displays many marvels of ingenuity and constructive skill only surpassed by man. But the spider still spins its web as it did millions of years ago. Aeons of change and development in living organisms have added nothing to the materials of construction used by the birds, beasts, fishes and insects.

The highest product of evolution is man, who acquired reasoning powers which first enabled him to abandon the clammy caves for the warmth and comparative security of a wood and wattle hut. From these dim beginnings he learnt to make bricks from clay ; to hew and carve the stone for temple and cottage. Yet, though he acquired skill to fashion rich architectural gems with greater spans of roof in wood and stone, his shelter was still earthbound.

With the advent of steel his imagination began to soar till now it has become essential to his needs in erecting structures of towering height. The progressive genius of man will find even greater scope in utilising the many forms of steel in the light, airy and spacious edifices for the cities of the future.

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Elihu Root

"We deem the independence and equal rights of the smallest and weakest member of the family of nations entitled to as much respect as those of the greatest empire."

Elihu Root will long be remembered for his brilliant statesmanship as secretary of war, secretary of state, United States senator for New York, and other responsible government positions, from 1899 to 1918.

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THERMOCOUPLE Protection Tubes

For use in furnaces and liquid heating mediums

MISCO rolled thermocouple protection tubes give more than customary protection to thermocouples. Walls are thin, accurate, absolutely uniform, giving quicker response to temperature variations. At the same time they are sounder, denser, more durable than heavier tubes of cast construction. They never fail to outlast cast tubes under identical conditions and offer best protection against heat and corrosion.

Made in several analyses to suit requirements, Misco rolled thermocouple protection tubes assure satisfactory results in operating temperatures up to 2200°F. Available in all diameters and lengths with threaded or plain ends. We will be glad to quote upon request.

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Copper... or Stainless... or Nickel... Brass, Bronze or Silver... one side or both sides... any thickness desired.

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Saving a great tonnage of copper every month in vital military applications *now*, SuVeneer Clad Metal will march into the homes of America after Victory . . . saving household dollars, delivering better service, providing finer appearance! This exclusive Superior development brings a unique clad metal to the hand of the modern designer—in convenient strip form which can be shaped by any of the standard methods.

New metal-ware for tomorrow's kitchens is but one of many SuVeneer Clad Metal applications *worth knowing* for the future. May we work with you?

Superior Steel
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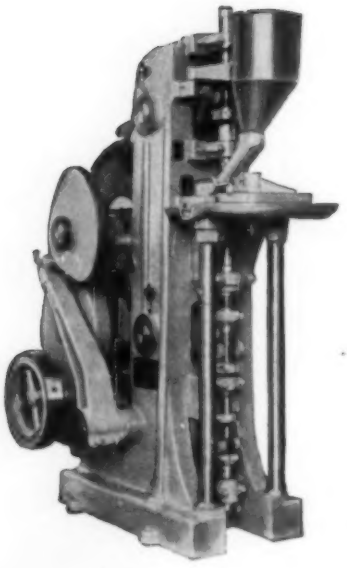
Pressed from Powdered Metals

STOKES PRESSES

Save Labor, Time, Materials



These parts are typical of hundreds being pressed from powdered metals . . . ordnance components, iron gears, porous bearings, parts for electrical assemblies, radio, communications systems, Alnico magnets, hard carbide tool bits, etc. . . . on Stokes Automatic Presses.

Stokes pioneered the development of this type of press . . . equipment which is the result of 25 years of research . . . and is constantly engineering new models in capacities and types to meet ever-widening applications.

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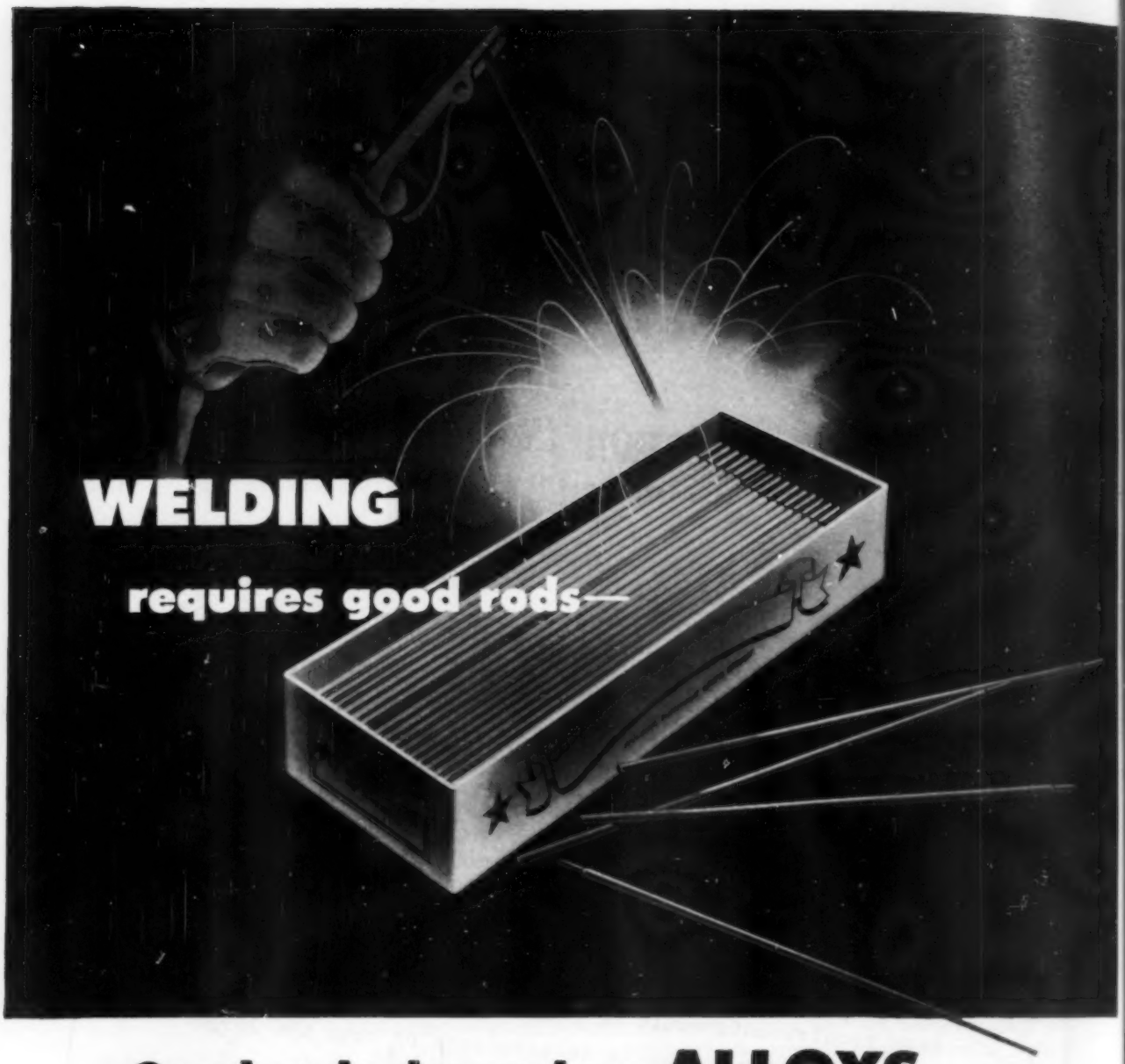
F.J.Stokes **AUTOMATIC TABLETTING EQUIPMENT** **FJS Est. 1895**



Good rods depend on ALLOYS

The tremendous increase of production in our metal-working industries has been due to many factors, among which welding is important.

Welding rods of highly specialized character are required for varied and exacting uses; and to meet the need, alloys enter more and more into welding rod manufacture.

Alloys are incorporated either in the coating or in the rod itself — either for fluxing purposes or to make the weld stronger.

The Molybdenum Corporation has for years been a large supplier of alloys, metal powders, and chemicals for the welding rod manufacturer, among its products being these:

Ferro-Molybdenum • Powders of Molybdenum
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Any inquiry concerning the availability of Molybdenum, Tungsten, or Boron will be gladly answered.

AMERICAN Production, American Distribution, American Control—Completely Integrated.

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ANNOUNCING A NEW NAME FOR HOUGHTO-QUENCH NE

HOUGHTON'S MAR-TEMP FOR SALT BATH QUENCHING

The term "Martempering" has, in a few short months, earned national recognition among metallurgists. Originally this process of "interrupted" quenching was applied to the lean alloy steels such as the NE Series where cracking and distortion too often resulted from a conventional quench.

As the work with salt bath quenching developed, it was found applicable to many steels other than the NE Series, therefore the former name "Houghto-Quench NE" came to be confusing in its apparent limitation of the process.

With the growing interest in Martempering, Houghton, originator of a salt for this specific purpose, has decided to rebrand this material and now offers *Mar-Temp* as a definite contribution to metal processing.

Houghton's Mar-Temp has the following characteristics:

1. **Possesses rapid quenching speed through critical zone from 1300° to 1000° F.**
2. **Has low melting point.**
3. **A fluid, low-viscosity salt with high thermo-conductivity.**
4. **Stable . . . no sludge . . . no scaling . . . permits final machining before heat treating.**
5. **Minimum carry-away losses.**
6. **Easily cleaned from the steel.**

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DIE STEELS

COBALT CHROME
AIR HARDENING

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AIR HARDENING

GSN
OIL HARDENING

FOR MAXIMUM PRODUCTION RUNS

TYPICAL ANALYSIS

	C	Si	Mn	Cr	V	Mo	Co
GSN Oil Hardening	2.20	.50	.50	13.20	—	—	—
GSN SPECIAL Air Hardening	1.50	.30	.30	11.50	.30	.70	—
COBALT CHROME Air Hardening	1.35	.50	.25	12.50	—	.70	3.00

These steels are playing their part in making possible the vast production of war materiel. They help provide the Dies, Punches, Gauges and many other precision tools that must produce and keep producing the countless parts that go into our planes, ships, tanks, guns and ammunition.

One of our service engineers can help you determine which of these essential Latrobe Steels will best meet your requirement, thus assuring you of *maximum production runs!*

TOOL STEELS FOR VICTORY

LESCO

Latrobe ELECTRIC STEEL COMPANY

MAIN OFFICES *and* PLANT · · LATROBE · PENNSYLVANIA

This Pantograph Shoe of High-Chromium Iron Lasted 10 Years

TEN YEARS of sliding metal on metal is a severe test for any abrasion-resistant material. But that is the record of this pantograph shoe, the trolley contact for a mix car in a metallurgical plant. After 10 years the shoe made of about 27 per cent chromium iron is still in service. Shoes of other grades of hardened steel on the same job last four months.

Iron castings of 26-28 per cent chromium outperform other commonly used wear-resistant metals and alloys in applications involving extreme wear . . . particularly where there is considerable abrasion without undue shock. These castings are unusually easy to cast.

Castings of high-chromium iron have given outstanding service in dredge-pump liners, sludge-pump liners for oilwell drilling, equipment for coke crushing, screening, and conveying systems, and rock-handling equipment such as crusher jaw plates, crusher rolls, and chute liner plates.

High-chromium high-carbon irons are readily made in either the crucible or electric furnace by melting procedures customary for high-chromium steels. For information on their composition, heat-treatment, and physical properties, write for the booklet, *Abrasion-Resistant High-Chromium* Iron.

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Unit of Union Carbide and Carbon Corporation
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Electromet
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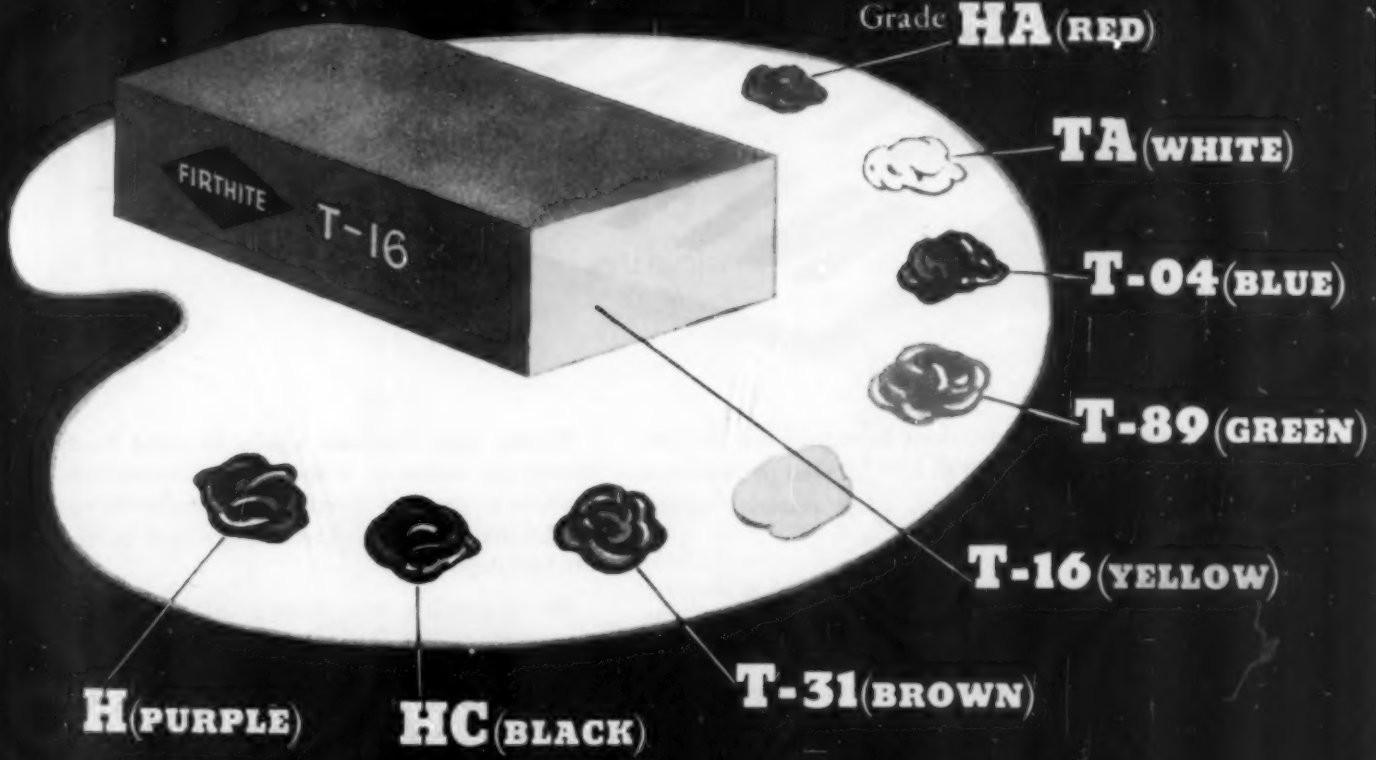
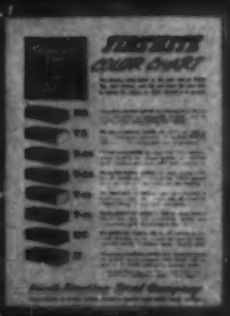
Firthite "Color-Branding" GETS A BIG HAND FROM COAST TO COAST



COLORS, on Firthite Sintered-Carbide Tips, are proving a most popular means of telling one grade from another. The color scheme recently introduced by Firth-Sterling, as another service to Firthite users, sets a convenient standard for the industry. A Firthite Engineer will gladly explain how this color system can be used to advantage in your shop.

Send for COLOR CHART

Handy guide to selection of Firthite



Firth-Sterling Steel Company

OFFICES McKEESPORT, PA. NEW YORK HARTFORD PHILADELPHIA CLEVELAND DAYTON DETROIT CHICAGO LOS ANGELES

Necessary war restrictions have confined the use of NITRIDED NITRALLOY to vital parts of war equipment for which no other material would produce the required hardness.

The important fact to bear in mind is that use of Nitralloy is permitted where only Nitralloy will produce the wanted maximum assurance of extreme surface hardness and desired core properties, insuring greatest possible resistance to wear and fatigue. It is still true that Nitrided Nitralloy produces the hardest steel surface known.

When Nitralloy can again be used freely throughout industry, it will rapidly return to its position as the first choice of manufacturers who design their metal products for greatest possible life and dependability.

For a possibly new concept of hardness, its measurement and its reduction to dimensional analysis expressed in terms of length, mass and time, write us for new book "Hardness". It is yours on request with our compliments. In writing, kindly use your business stationery and official signature.

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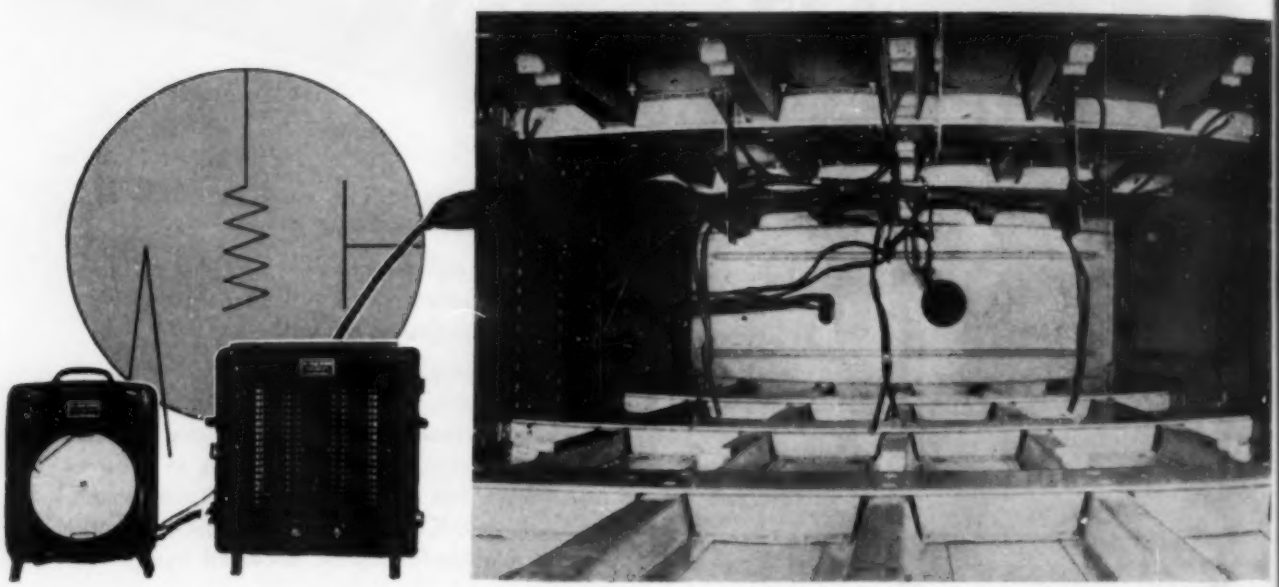
—NEW PROGRESS—
in Instrumentation
with *Electronic Sensitivity!*



Measuring strains in airplane wings is one typical use of electronic instruments developed by Foxboro. Electronic Recorder, at left, gives exact, rapid readings of 48 SR-4 strain gages located inside wing, as shown above.

Initial successes foretell industry-wide application of *DYNALOG* Electronic Instruments!

Again, the first "milestones" to an important new phase of process measurement and control have been established by Foxboro. This time, it is through successful "key" applications of *electronic sensitivity* in instruments to give new degrees of manufacturing precision!

For more than eight years, Foxboro Verigraph Electronic Instruments have been widely used by rubber and paper industries for sensitive weight-and-moisture measurements. Continued original research has brought new developments in Foxboro electronic instrumentation.

Today, in war-essential installations, electronic instruments by Foxboro are making instrument history . . . measuring strains with unique speed and accuracy . . . furnishing continuous precision records of torque . . . keeping track of temperature with exactness never possible before!

Tomorrow, when peace returns, Foxboro's new DYNALOG Instruments will be available to all industry for these and other important applications. DYNALOG Instruments will vastly simplify many difficult process control problems . . . will furnish the first practical instrumentation ever developed for some industrial operations!

The Foxboro Company, 52 Neponset Avenue, Foxboro, Mass., U. S. A. Branches in principal cities.

A STAR IS ADDED . . . For continued outstanding production, The Foxboro Company has won renewal of the Army-Navy "E" Award.

DYNALOG **measurement and control by** **FOXBORO**

Reg. U. S. Pat. Off.

You can't teach an *Old Dog* new tricks

So says the proverb!

Yet, almost overnight, American shipbuilders—"old dogs" at their business—*learned* the entirely "new trick" of constructing steel cargo vessels and war vessels by welding. If they hadn't, the "bridge of ships" that made the conquest of North Africa and the invasion of Europe possible would still be just a pipe dream.

Contributing much to the shipbuilding industry's phenomenal production records is the "researched line" of **McKay Welding Electrodes,** a preponderance of which now goes into all-welded ship construction.

In addition to these **McKay Electrodes** of Stainless, Alloy, or Mild Steel for every welding purpose, **McKay Chain**—its production stepped-up more than 400%—plays a vital role in maritime uses; and **McKay Tire Chains** help maintain the efficiency of both civil and military transportation.

It's no "trick" to learn how the McKay line can speed *your* production schedule.

Simply write us!

GENERAL SALES OFFICES: YORK, PA.

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PITTSBURGH, PA.

WELDING ELECTRODES . . . COMMERCIAL CHAINS . . . TIRE CHAINS

BOEING FLYING FORTRESS

The Fort's Forte

This is *not* just another Flying Fortress.

Instead, we like to think of it as a symbol for all Fortresses . . . for the one that limped home, almost sawed in half by a wild, mad Messerschmitt . . . for the one that pulled out of a dive at almost 450 m.p.h.! Or perhaps it's the forerunner for future Forts that will blast hallelujah out of Hitler and Hirohito.

You'll note the same theme running through each success story – performance with *dependability*. That's the Fort's Forte and that's where we come in. Triplett & Barton performs X-Ray inspection on all vital stress castings for every Flying Fortress. That gives positive assurance against structural failure and saves valuable machine time otherwise wasted on defective parts.

Your metal problems are welcomed by Triplett & Barton specialized technicians. Call or write for information on how these services can help you: X-Ray and Gamma Ray inspection–Physical and Electrical testing –X-Ray Diffraction–Chemical and Spectrographic analysis–Metallography–Heat Treatment and Foundry Sand Testing–Hi-Speed and Microphotography and others.

X-RAY

TRIPLETT & BARTON INC.

METALLURGICAL DIAGNOSIS

WICHITA, KAN. **BURBANK, CALIF.** SEATTLE, WASH.

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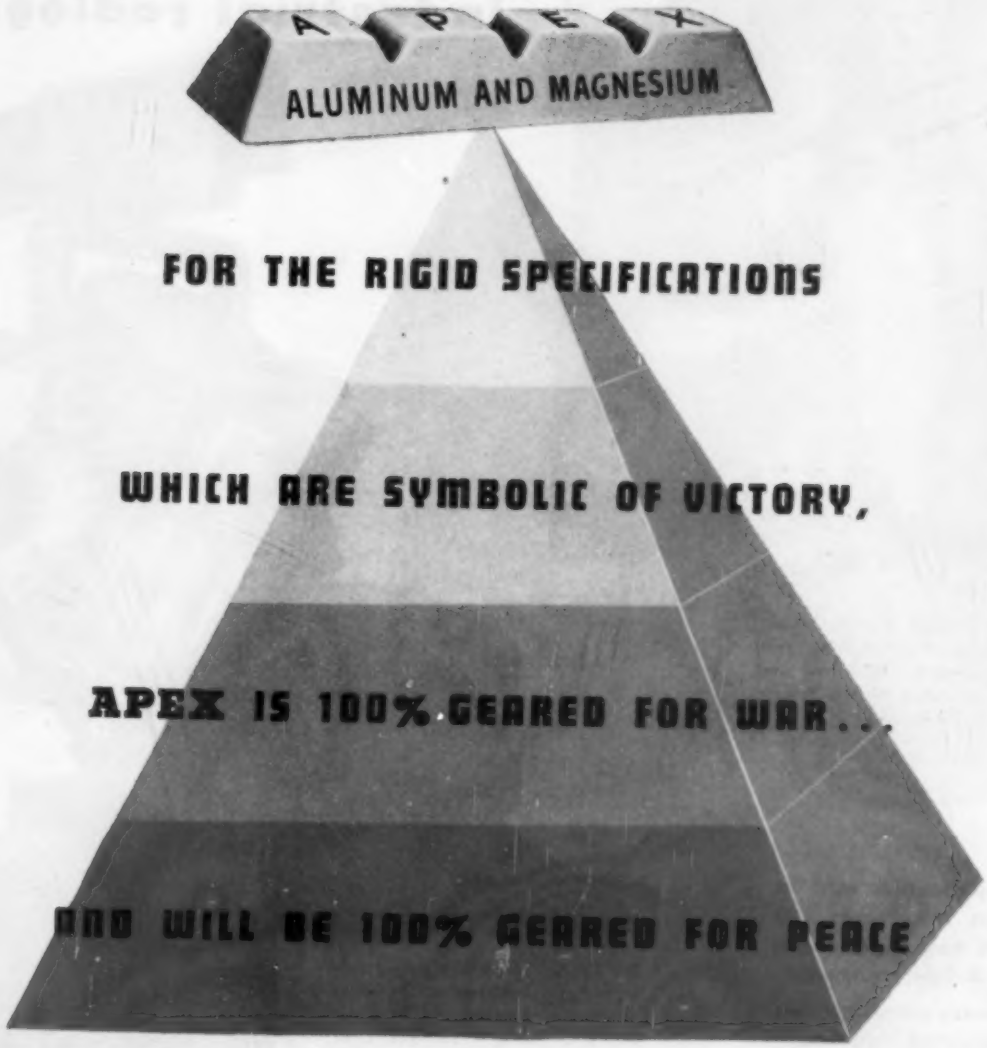

SMELTING

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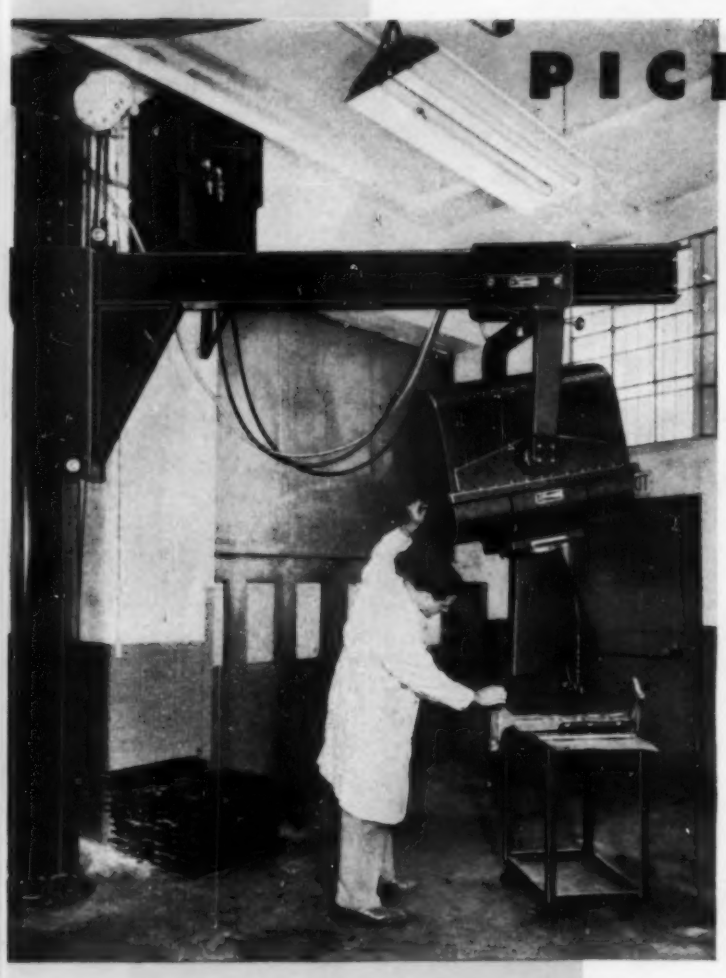
CHICAGO, ILLINOIS

PICKER 250 KVP JIB CRANE for heavy-duty industrial radiography



The transformer-tubehead, at high elevation, radiographing a light metal casting. A detachable cone is here employed to reduce scattering. Note how cooling is effected by an oil current circulating through lines leading from the wall mounted cooler.

The 250 KVP Jib Crane radiographing a heavy steel section. The entire transformer-tubehead can be aimed with practically fingertip control.

In versatility of application and in soundness of design, this Picker 250 KVP Apparatus sets new high standards for industrial X-Ray equipment.

Free movement in every plane endows the Jib Crane Mounted tubehead-transformer with fingertip facility for angular positioning.

Massive castings of awkward contour are radiographically inspected with the same ease as light portable objects.

Flexibility of the Unit permits progressive inspection of prescribed areas around the circumference of massive castings. Positive voltage control at continuous 15 milliampere rating.

The Picker 250 KV transformer-tubehead can also be supplied mounted in a mobile truck, complete with rayproof operating booth, for applications where mobility is essential. It is also available mounted on a rail dolly. The Picker engineering staff and research facilities are at your service for any special applications, or for consultation on special problems.

this versatile **250 KVP Jib Crane X-Ray Unit**, cker presents a soundly engineered appara- s based on exhaustive study of the heavy- ty radiographic requirements of many di- rse industries.

wide scope of operational efficiency pro- des comprehensive radiographic facilities tending over a vast spread of materials d section thicknesses, from light alloys to " steel (with screens).

This is the Picker 250 KV self-contained trans-former-tubehead. Sixty-four years of experience in the manufacture of high voltage apparatus have gone into its design, which incorporates the following outstanding features:

1 **SELF CONTAINED.** Rayproof X-Ray tube and transformer oil-immersed in sealed, shockproof tank.

2 **NO EXTERNAL HIGH TENSION CABLES.** Improved Picker design eliminates need for high tension leads through U. S. Patent No. 1,334,936.

3 **LOW INHERENT FILTRATION.** Assures increased radia- tion output.

4 **FLEXIBILITY.** Trunnion-mounted tubehead swings freely in all planes, permitting universal angular positioning.

5 **CONTINUOUS OPERATING CYCLE.** Continuous opera- tion at 15 milliamperes.

6 **HIGH EFFICIENCY COOLING.** Circulating oil pressure system requires no outside water supply.

7 **POSITIVE POSITIONING.** Jib boom is raised or lowered with positive control, by motor-driven chain hoist. Entire assem- bly locks firmly at any angulation.

8 **WIDE OUTPUT RANGE.** Output range from 30 KV to 250 KVP, with time voltage control, is adapted to radiography of variety of materials, from light alloys to heavy steels.

9 **INSTANT TUBE ACCESSIBILITY.** X-Ray tube is readily accessible for examination or replacement by simply removing special leak-proof access cover. No time-consuming disassembly necessary; no operational tieups required.

Instant tube access

no disassembly . . . no operating delays

First "E" Award in the X-Ray Industry

PICKER X-RAY
CORPORATION
300 FOURTH AVENUE • NEW YORK 10, N. Y.
AITE MANUFACTURING DIVISION • CLEVELAND, OHIO
TORONTO PICKER X-RAY OF CANADA, LTD. MONTREAL

ANUFACTURERS OF HIGH VOLTAGE ELECTRICAL APPARATUS SINCE 1879

THERMONIC

THE MOST EFFICIENT AND ECONOMICAL SYSTEM FOR INDUCTION HEATING

HITLER & CO. SHIVER WHEN THIS "ORGAN" PLAYS

The "organ" reproduced to the right, and so vividly dramatized by Noblitt-Sparks, is a Thermonic production set-up. It "plays off" an "octave" of highly specialized brazes every 65 seconds . . . 440 per hr!

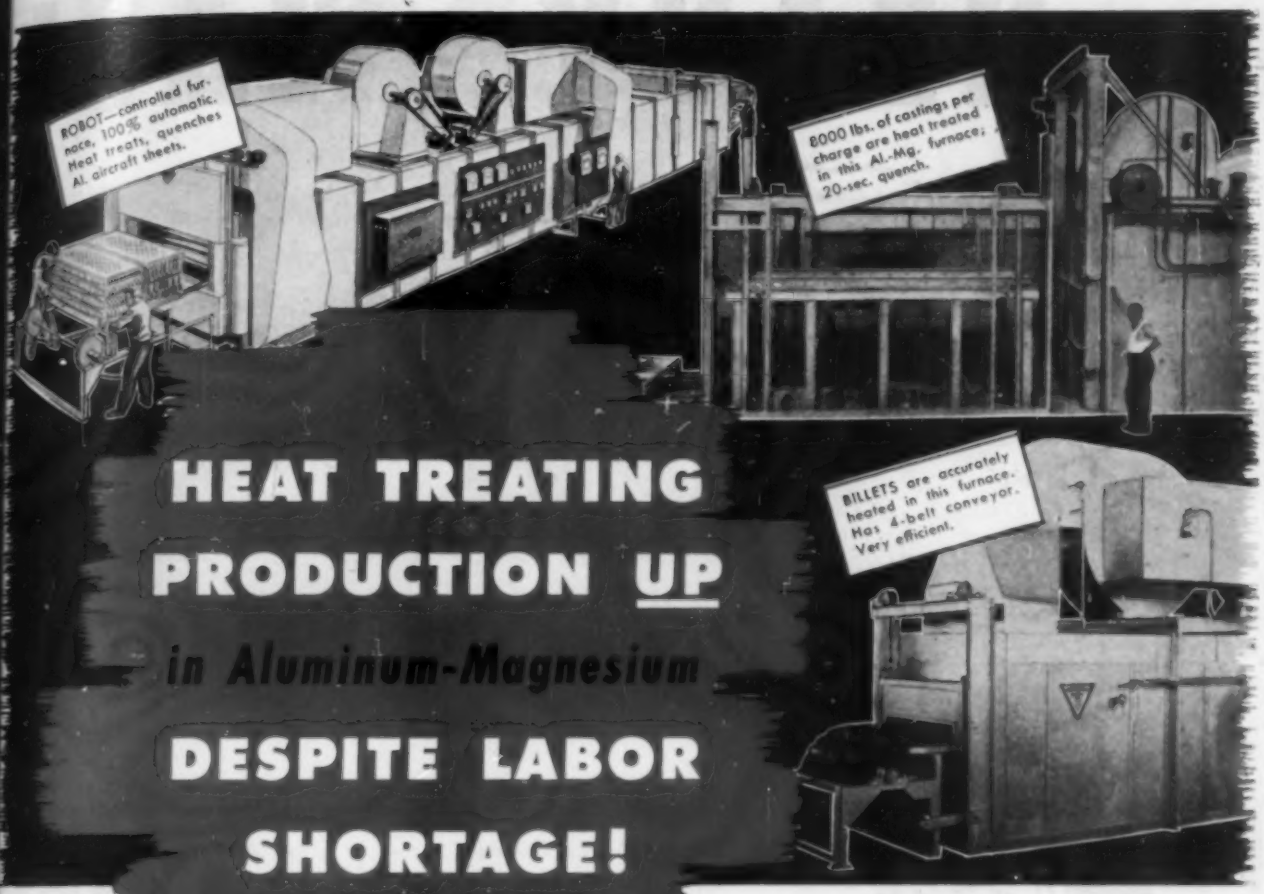
The tall, pipe-like parts shown at the right are burster wells (aerial bomb exploders) in the stage of going through an important brazing step, while the large central illustration visualizes the actual operation involved. The requirement here called for brazing a small screw machine part onto the end of a steel tube . . . the condition being that the inside threading of the pieces be kept free from the flow of the brazing alloy!

That this brazing operation was successfully and speedily accomplished by Thermonic is in no uncertain terms indicated by the Noblitt-Sparks copy headline! It packs a knock-out punch!

The versatility of Thermonic Induction Heating equipment is doing much to speed up vital war requirements. . . . It is boosting production by reducing, from minutes to seconds, operations calling for Brazing, Hardening, Forging, Melting and Annealing. . . . It cuts power and maintenance costs to fractions. . . . And unskilled labor quickly becomes expert in handling its many functions. For complete information about our equipment's proven advantages, we invite your inquiries. The counsel of Thermonic's engineering staff is at your service.

INDUCTION HEATING CORPORATION . 389 LAFAYETTE STREET, NEW YORK 3, N.Y.

Largest Producers of Electronic Heat Treating Equipment for Brazing Melting Annealing Forging Hardening



HEAT TREATING PRODUCTION UP *in Aluminum-Magnesium* DESPITE LABOR SHORTAGE!

How automatic operation of Despatch furnaces assures better results, demands less skill

By eliminating manual effort in many operations, Despatch furnaces are helping non-ferrous heat treaters chalk up an amazing production record this year despite labor shortage. That's why, with 1944 slated as being more serious yet from the manpower standpoint, a Despatch furnace is an exceptionally valuable investment *now*.

ROBOT CONTROLS AVOID ERRORS, HELP WORKERS

Spectacular, yet typical of Despatch engineering accomplishments, is the furnace above (at left). It *automatically* transports, heat treats, spray quenches and discharges hundreds of aluminum sheets hourly. Robot-controlled mechanism does the work. Result: *highest quality heat treatment* . . . human error reduced to minimum . . . need for skilled workmen avoided . . . and manpower saved for more efficient use elsewhere in the plant.

All Despatch furnaces for non-ferrous heat treating, from small batch models to largest conveyors, assure dependable operation with the minimum of attention. *Write or wire for full details today.*

These Features Help Maintain Peak Output

AUTOMATIC CHARGING
. . . in conveyor models carries load through chamber at desired speed. Needs no watching. Available with synchronized door operation if desired. Ideal for large scale production of castings, sheets, preforms, billets, etc. *Ask for photos of typical installations.*

AUTOMATIC HEAT CONTROL
. . . is maintained within closest limits in conjunction with uniform heatflow through chamber. New forced convection system developed by Despatch engineers is used. Assures best possible results in heat treating to difficult specifications. Zoned heating provided on larger units. Straight-line temperature control guaranteed. *Ask for performance details.*

AUTOMATIC QUENCHING
. . . within seconds is available on some models, semi-automatic quench systems on others. Allows largest loads to be handled easily. *Write for diagrams explaining quench systems used.*

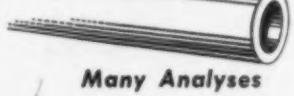
DESPATCH OVEN COMPANY MINNEAPOLIS

WRITE TODAY for latest helpful bulletins, photos and data. Prompt attention assured

HEAVY WALL

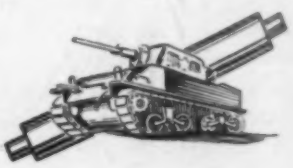
The Rockrite Process

Rockrite is a complete departure from the long used cold-drawing process of sizing tubes. It is the modern method whereby semi-circular, grooved dies rock back and forth over the tube compressing the metal against a mandrel which controls the inside diameter.



Many Analyses

The Rockrite Process is adaptable to many analyses of steel and other metals including a large number which are difficult or impossible to size by cold drawing. Among the metals readily processed are SAE 52100 steel, stainless steels, Beryllium alloys, aluminum, copper and alloys of aluminum and copper. Sizes at present are limited to 3⅛" O.D. and smaller.



Tank Track-Pins

"Pins" that join and hold tank tractor treads in place—in spite of boulders, trees, and mire—are made from Rockrite heavy-wall tubing. Agricultural-implement manufacturers please note—post-war idea here.

L TUBING.....

..... ordinarily "difficult"....

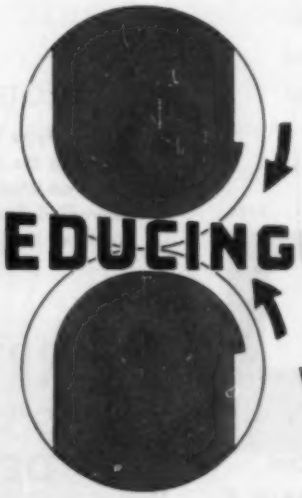
a Rockrite Specialty

Some new, and perhaps startling, economies in the production of round or cylindrical parts of small diameter and small bore will be attainable during the post-war era. In the past many of these parts were finished from bar stock, or forgings . . . the use of tube stock was impractical. Small-diameter heavy-wall tubing was difficult to manufacture, its cost was high and often its dimensional tolerances were not close enough to permit economical machining.

Rockrite Tubing will change this situation . . . is doing it now for certain essential war products.

The Rockrite Process makes possible, and practicable the production of small-diameter heavy-wall tubing which, in many cases, is more nearly perfect in concentricity and with less ovality than has been obtainable by other processes. This means that parts made from Rockrite Tubing require less machining to correct for dimensional variations from the nominal. Sometimes no machining is necessary on the outside or inside. High Cutting speeds can be used without shortening tool life. And high physical properties can be combined with machineability.

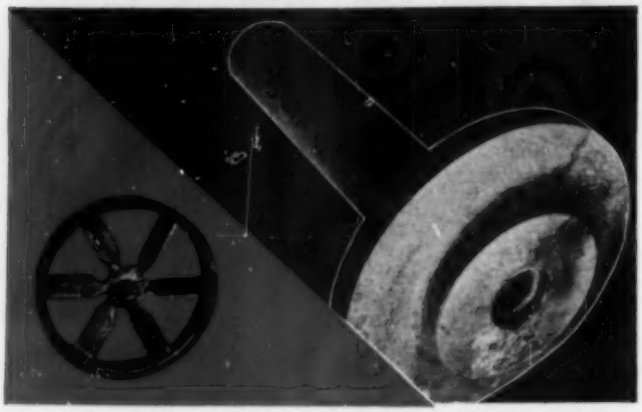
Inquiries from designers of post-war products are invited.



TUBE REDUCING CORPORATION

WALLINGTON, NEW JERSEY

DISSERTATIONS ON



DISSIMILARITIES

There is a great difference between a compressor pulley and a turret column, yet the castings for both require characterictics found in ABSCO Meehanite.

ABSCO Meehanite is not just another cast iron but is the name of a number of irons, twenty-one in all, each having a different combination of physical properties aimed toward meeting a distinctive need. These twenty-one types of ABSCO Meehanite are produced under four general classifications: 1. General Engineering; 2. Heat Resisting; 3. Wear Resisting; and 4. Corrosion Resisting.

Standard ABSCO Meehanite Castings provide high strength, vibration absorption qualities and best machinability. We will be glad to send full information concerning the physical properties of each type and a description of the various combinations which are available. We will also be glad to explain the many reasons why ABSCO Meehanite Castings are uniformly sound and dependable and how they are produced to close engineering specifications for important industrial applications.

3285

AMERICAN
Brake Shoe
COMPANY

BRAKE SHOE AND CASTINGS DIVISION
230 PARK AVENUE NEW YORK, N. Y.

COMBUSTION FURNACES

VARITEMP COMBUSTION FURNACE

The ideal laboratory furnace for accurate and rapid carbon and sulphur determination. Sturdily constructed and well insulated, the furnace is complete with transformer, pyrometer, power switch, and voltage control switches. Two rotary switches select the proper voltage for maintaining desired temperatures up to 2750° Fahr. The temperature is indicated by a compensated pyrometer on the front of the furnace.

GLOTEMP COMBUSTION FURNACE

A new type furnace with heating elements placed at right angles to the combustion tubes. Heat is efficiently applied to a restricted portion of the combustion tube creating an intensified heat zone which provides fast combustion of steel and iron samples.

Write for illustrated leaflet today

HARRY W. DIETERT CO.
9330 Roselawn Ave.
DETROIT 4, MICH.

STREAMLINED HEAT-TREATING...

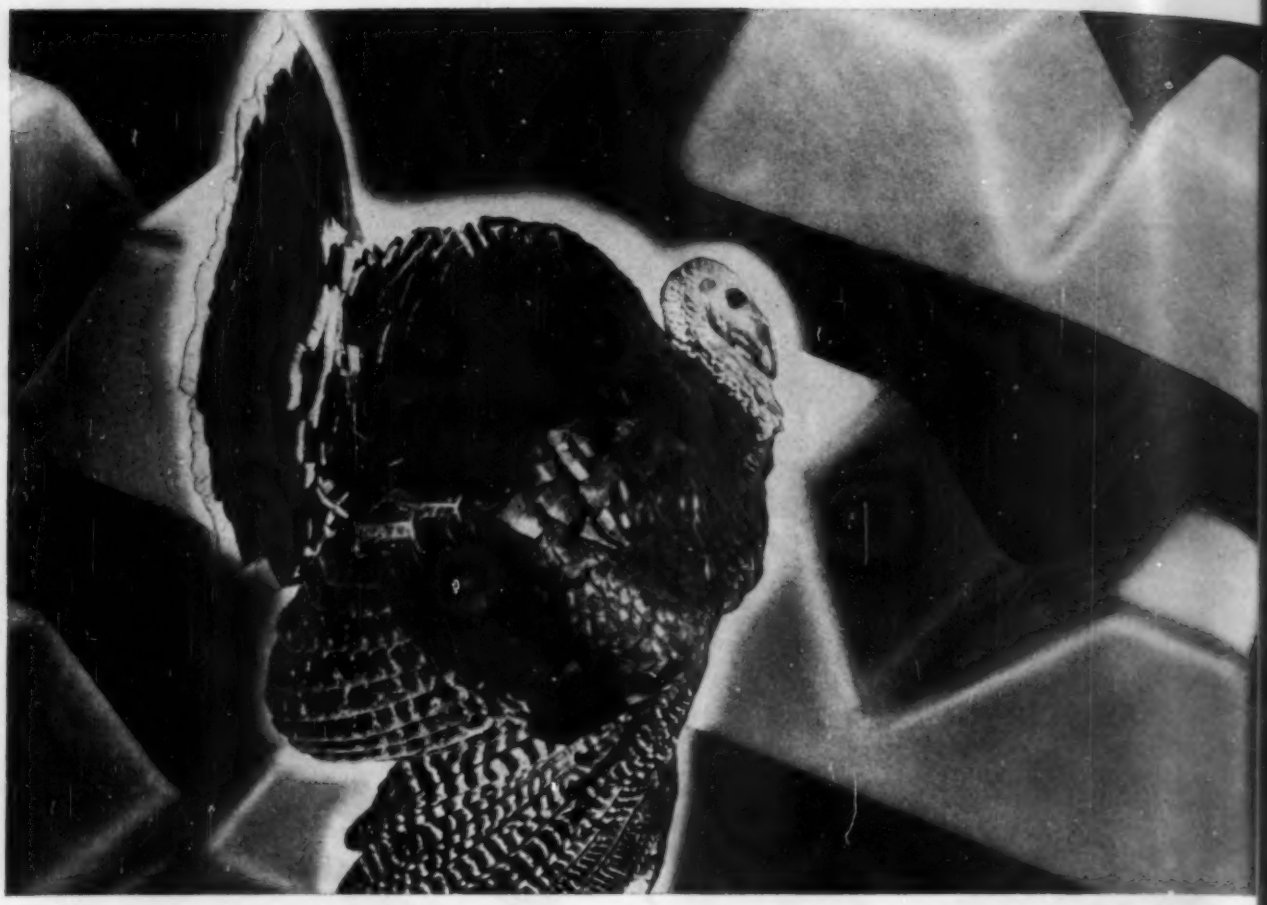
War's impact has evolved new techniques which will be valued post-war procedures

To "get thar fustest with the mostest men" means getting there "fustest" with machines of war as well—tanks, planes, ships, bombs, torpedoes, and a thousand other essentials. To do that, American industry has had to perfect new ways of turning out war materials—better, faster.

Because heat-treating enters so largely into the making of most war materials, Gas has played a vital part in this rapid evolution of techniques. One aspect has been the creation of a new technique by which heat-treating with Gas has been integrated with production so that each operation, whether heating or quenching, is not a separate task but an integrated part of the whole operation.

All this new development will be available to industry after the war and will unquestionably help to produce peacetime goods faster and better and at immensely lower cost. Ask your Gas company for help in fitting Gas to your post-war needs.

AMERICAN GAS ASSOCIATION
INDUSTRIAL AND COMMERCIAL GAS SECTION
420 LEXINGTON AVENUE, NEW YORK



LET'S TALK TURKEY ABOUT ALUMINUM ALLOYS

• It's about time to stop talking about *secondary* aluminum. *Any* aluminum alloy which meets the rigid specifications of the government and of technical societies is equal to its task. We—the undersigned companies—produce such alloys, under strictest laboratory controls.

The members of the Aluminum Research Institute are meeting the demands of war production with furnaces that smoke by day and flare by night, to furnish the ingots imperatively needed. We will meet the demands of postwar industrial expansion in common sense American fashion, with aluminum alloys that will play a crucial part in peacetime planning and achievement.

It's time to talk turkey: The war has proven the value of our product. The aluminum alloys that we produce have come of age. No longer should they be called "secondary." In peace as in war, our aluminum alloys will do a "primary" job.

Aluminum and Magnesium, Inc., *Sandusky, Ohio*

The American Metal Company, Limited *New York City*

Apex Smelting Co. *Chicago, Illinois*

The Cleveland Electro Metals Co. *Cleveland, Ohio*

Federated Metals Division American Smelting and Refining Company *New York City and Branches*

General Smelting Company *Philadelphia, Pennsylvania*

William F. Jobbins, Inc. *Aurora, Illinois*

R. Lavin & Sons, Inc. *Chicago, Illinois*

The National Smelting Company *Cleveland, Ohio*

Niagara Falls Smelting & Refining Corp. *Buffalo, New York*

Sonken-Galamba Corporation *Kansas City, Kansas*

U. S. Reduction Co. *East Chicago, Indiana*

ALUMINUM RESEARCH INSTITUTE

308 West Washington Street, Chicago 6, Illinois

Hardening NE Steels

WITH REJECTS LESS THAN 1%!

at JONES & LAMSON MACHINE CO.
Springfield, Vt.

◀ Neutral Hardening Section. Operator is removing jack shafts from the Ajax-Hultgren furnace. Jack shafts are suspended from adjustable fixture support brackets by hooks.

Close-up, showing special jigs and fixtures in use for neutral hardening operations at Jones & Lamson Machine Company. ▼

Jones & Lamson lathes, thread grinders, radial and tangent die heads, chasers, comparators, involve 90 different analyses including most NE steels, over 40,000 heat treated parts. . . . The Ajax electric salt bath furnace method is used for hardening these steels. After 13,000 hours of operation without discernible pot wear or maintenance, at temperatures from 1600° to 1700° F., Lester J. Sheehan, production metallurgist, has this to say:

"It has been our observation that the salt bath introduces fewer variables than any other method, providing all recording devices are checked, the bath kept circulating for temperature uniformity, and kept chemically neutral by proper cleaning. . . .

"Distortion, decarburization, hardness variations are eliminated. During a representative period of operation the salt bath furnace produced over a quarter of a million pounds of heat treated parts, with less than 1% average rejects."

Write for the full story of Neutral Hardening, and Send for Catalog 107-A.

(Top of Page): Jones & Lamson worm shafts at the upper left have been carburized, ready for hardening selectively at the worm end. The clutch shaft (NE 8749) is to be straightened from the quench at 550°. The two pilot bars are shown as quenched in brine. They are X1315 steel, carburized to .060". The two jack shafts of NE 8713 steel (carburized) have been quenched in oil. All parts achieve maximum hardness obtainable for their respective analyses and treatments.

AJAX ELECTRIC CO., FRANKFORD AVE. AT DELAWARE AVE., PHILADELPHIA 23, PA.

**THERE'S AN AJAX INSTALLATION NEAR YOU!*

THE AJAX HULTGREN ELECTRIC SALT BATH FURNACE

ASSOCIATE COMPANIES:
AJAX METAL COMPANY, *Non-Ferrous Ingot Metals and Alloys for Foundry Use*
AJAX ELECTROTHERMIC CORPORATION, *Ajax-Northrup High Frequency Induction Furnaces*
AJAX ELECTRIC FURNACE CORPORATION, *Ajax-Wyatt Induction Furnaces for Melting*
AJAX ENGINEERING CORPORATION, *Ajax-Tama-Wyatt Aluminum Melting Induction Furnaces*

BUYERS' GUIDE APPEARS IN JANUARY

✱ Hundreds of manufacturers have deluged Metal Progress offices with lists of products for insertion in the January Buyers' Guide section of the magazine. To be published as section two, the Buyers' Guide will go to a guaranteed circulation of 20,000 men in the metal industries.

It will be the 7th edition of an engineering buyers' reference that has high established usership in the industry.

LIGHT METALS MARKET

✱ We get a great many inquiries regarding markets in the aluminum and magnesium field, and we try to give accurate replies. But it's difficult to keep up with an industry that's zoomed its 1943 production to 2,100,000,000 lbs. of aluminum and 450,000,000 lbs. of magnesium! This calls for a tremendous number of melting furnaces, heat treating furnaces, forging, welding and miscellaneous fabricating equipment. We can't give you exact day-by-day requirements of the industry—but we can show you how the metal engineer fits into this market—and can help you.

"FACTS FOR '44"

As you consider 1944 advertising sched-
ules, this new sixteen-page catalog o
facts on 17,639 metal engineers ma
prove helpful to you.

For here is a booklet that shows how, and why, and where these engineers of the metal industry fit importantly into your plans for this great market.

This booklet gives you a check list of products that are used and specified by metal engineers. It gives you their editorial interests and their reading preferences.

"Facts for '44" shows you how to obtain top engineering coverage of the metal industry — at substantial savings in your advertising budget.

Let us send you your copy today.

ENGINEERING HEADQUARTERS FOR THE METAL INDUSTRY

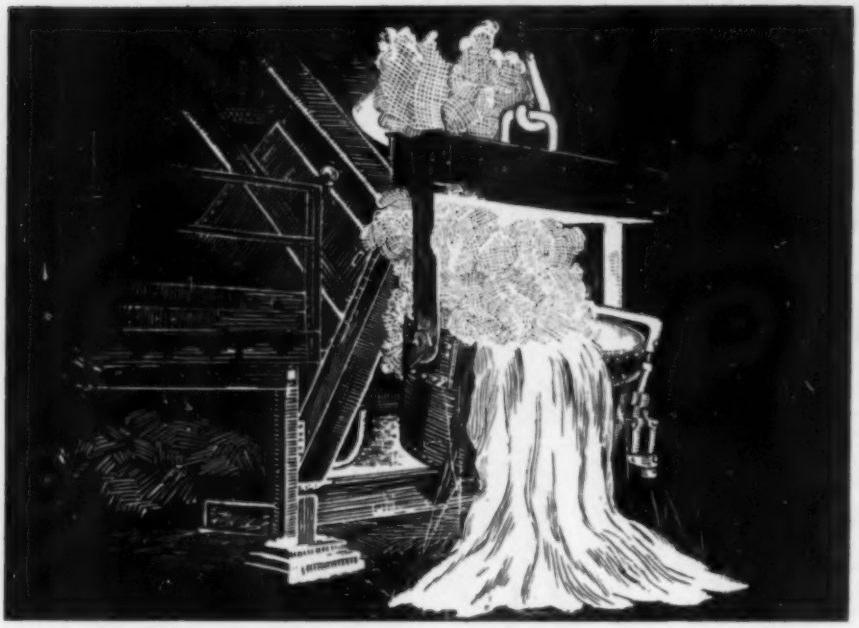
Metal Progress

PUBLISHED BY AMERICAN SOCIETY FOR METALS

7301 EUCLID AVE. CLEVELAND 3, OHIO

UP IN FRONT

✱ More engineers in the metal industry are reading Metal Progress than ever before. In fact, as 1944 approaches, nearly 18,000 metal engineers are looking to Metal Progress for the news of developments in their industry. This is the top circulation available today. It would be a pleasure to show you how economically you can reach this market—and how effectively.



NORTON REFRACTORY CEMENTS are giving long, trouble-free service in metal melting furnaces because of their ability to withstand high heat and remain chemically stable. For example:

CRYSTOLON (silicon carbide) 1131 CEMENT — a highly refractory mixture for ramming into oil or gas fired reverberatory and pit furnaces melting aluminum. Also recommended for melting copper and zinc.

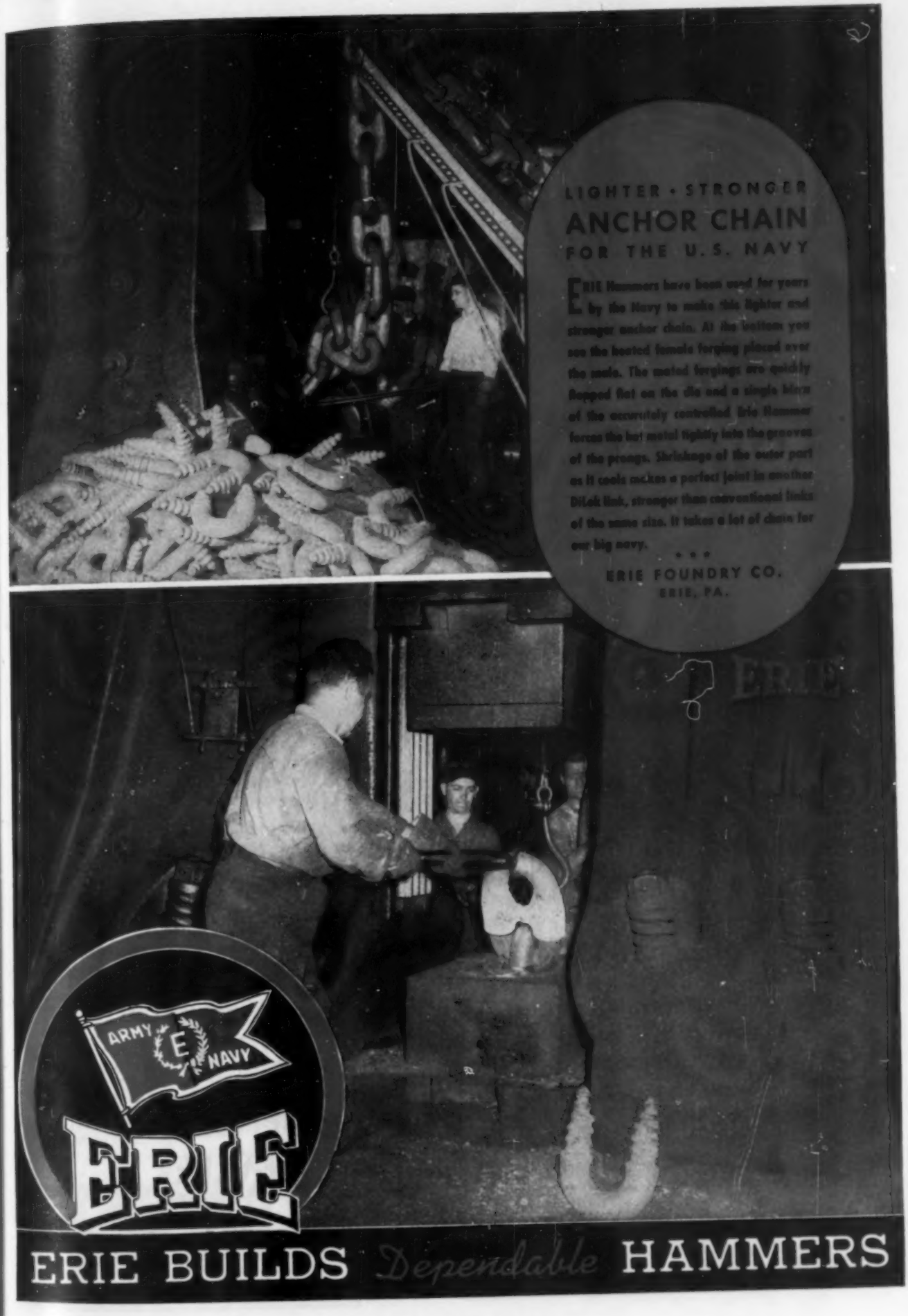
RM 1169 CEMENT — a fused magnesia mix, ideal for lining Ajax-Northrup high frequency furnaces melting nickel-chromium alloys. Has given up to 400 heats in 600 to 1000 pound furnaces.

ALUNDUM (electrically fused Al_2O_3) 889 CEMENT — recommended for lining burner tunnels in gas or oil fired billet heating, heat treating and annealing furnaces.

RM 1140 — a fused magnesia cement for rammed linings in Ajax-Wyatt low frequency vertical ring induction furnaces melting high copper alloys (more than 85% copper), copper-nickel alloys, nickel silver, and cadmium bronzes.

R-861

NORTON COMPANY
Worcester 6, Massachusetts


LIGHTER • STRONGER
ANCHOR CHAIN
FOR THE U. S. NAVY
ERIE Hammers have been used for years by the Navy to make this lighter and stronger anchor chain. At the bottom you see the heated female forging placed over the male. The mated forgings are quickly flopped flat on the die and a single blow of the accurately controlled Erie Hammer forces the hot metal tightly into the grooves of the prongs. Shrinkage of the outer part as it cools makes a perfect joint in another DiLok link, stronger than conventional links of the same size. It takes a lot of chain for our big navy.
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ERIE FOUNDRY CO.
ERIE, PA.
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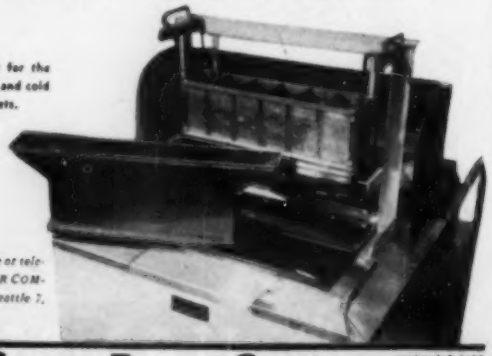
ERIE BUILDS Dependable HAMMERS

Your inquiry

may save you thousands of dollars

may save precious production hours

THAT'S THE record of Sweden Freezer equipment at Boeing, home of the great "Flying Fortress"! Let it do the same for your plant. This superior mechanical equipment for the heat and cold treatment of aluminum alloy rivets and formed parts gives perfect results every time. There is no rivet splitting to slow production and increase costs. Parts can be held to fit into press production programs without danger of premature aging. Sweden Freezer, pioneers in this field, has all the facilities to design and construct equipment to fit your needs. Your inquiry today may result in increased production tomorrow. Write, wire, telephone. Let us tell you about this fine equipment that has been developed successfully from many years' experience.



Sweden Freezer Cabinet for the complete control of heat and cold treating of aluminum rivets.

For full details write, wire or telephone SWEDEN FREEZER COMPANY, *1140 West 53rd, Seattle 7, Washington.*

Manufacturers of Aluminum Alloy Heat Treating Equipment

Sweden Freezer Company

1140 WEST 53RD SEATTLE 7 WASHINGTON

Here's How. . .

WE WIN FRIENDS at Benedict-Miller

Today's allotments, priorities, government reports, etc., often seem to make the job of producing VICTORY unnecessarily difficult. We at Benedict-Miller wish there were simpler means of doing *our* job—for *your* benefit.

For the present, however, it seems as if good old hard work—overtime by *both men* and *machines*—is the best way of our insuring you the continuation of a steel service that is efficient, friendly, helpful—specializing in

Alloy and Carbon Grades . . . As Rolled, Annealed and Heat Treated Machinery Steels . . . Cold Finished and Hot Rolled . . . Tool Steels . . . High Speed Steels . . . Drill Rod . . . Tool Bits . . . Simonds Flat Ground Stock . . . Special Plates . . . Flame Cutting . . . Diamond Broach Hack Saws.

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BENEDICT-MILLER INC.

216 Clifford St., Newark, 5, N. J.

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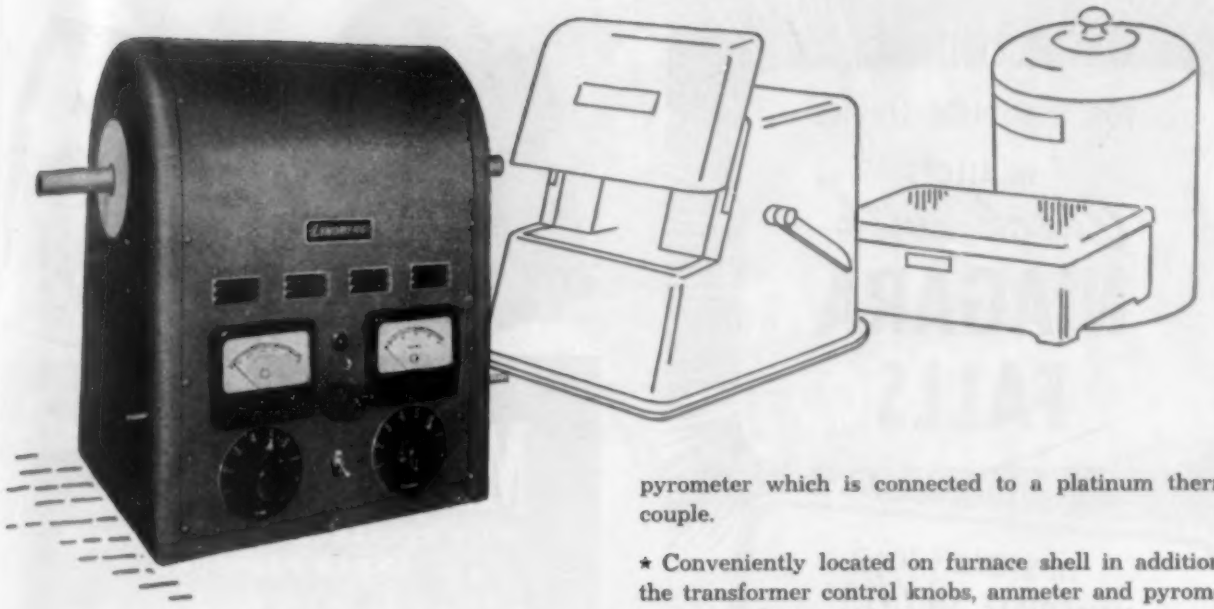

Dependability
IN YOUR LABORATORY!

THE NEW LINDBERG LABORATORY FURNACES AND HOT PLATES are engineered for dependable performance and built for long life. In addition, they are designed to add to the high standard of present day laboratory cleanliness. Even the most fastidious technician will appreciate the modern streamlined appearance Lindberg equipment presents.

Pictured above is the Lindberg Combustion Tube Furnace. Let's glance over the many important features you can benefit by in your laboratory.

* Because of the high temperatures obtainable, this furnace is ideal for fast modern volumetric methods of carbon or sulphur determination as well as gravimetric determination on carbon and all alloy steels, including stainless and heat resisting steels.

* Three low voltage, high temperature Globar elements permit continuous operation with temperatures up to 2500°F. or for occasional operation to 2650°F. Heating elements are easily accessible — no inconvenient dismantling and assembling job required to replace them. Temperature is regulated by a built-in variable voltage transformer with coarse or fine adjustment for amperage control. Adjustment is made by merely making the necessary settings with the amperage control knobs.

* An ammeter is provided to show the proper and safe current required for the Globar heating elements. The temperature in the combustion zone is indicated by a pyrometer which is connected to a platinum thermocouple.

* Conveniently located on furnace shell in addition to the transformer control knobs, ammeter and pyrometer are a pilot light which shows when furnace is in operation; an on and off switch; and adjusting knob for controlling oxygen flow through a needle valve and rubber tubing adapters connected to the needle valve.

* Furnace is equipped with adapters for easy interchangeability of tubes. Three sizes of tubes, 1", 1¼", and 1½" O.D. can be adpated, while fourth tube, 2" O.D., can be used without adapters.

* For 60 cycle, AC current with voltage at either 110 or 220 volts. Furnaces for 25 cycle operation can also be supplied.

See your dealer today. He will be pleased to go over your requirements and point out the advantages you get with the new Lindberg Combustion Tube Furnaces, Box Furnaces, Crucible Furnaces and the new laboratory Hot Plates.

LINDBERG

Well-known Throughout the World as the Leaders in Developing and Manufacturing Industrial Heat Treating Equipment

ARMY E NAVY

LINDBERG ENGINEERING COMPANY
2450 WEST HUBBARD STREET, CHICAGO 12, ILLINOIS

SOLD EXCLUSIVELY THROUGH LABORATORY EQUIPMENT DEALERS

MAC DERMID Inc. COMPOUNDS ARE *FASTER* AND *BETTER* BECAUSE THEY ARE INDIVIDUALLY FORMULATED!

Write and be Right

Get these informative, new folders now and learn how to secure chemically and metallurgically clean metals by using the original ANODEX PROCESS for electro-plating . . . See the many new METEX COMPOUNDS that have been developed for individual cleaning operations.

MacDermid Inc., manufacturers of compounds for cleaning metals since the last world war, have been "all out" for victory since this war started . . . Today MacDermid Inc. chemists have perfected and had approved over fifty formulae *individually developed* for specific cleaning problems that are guaranteed to speed-up and improve pre-finishing or pre-coating production and reduce overall operating costs through savings in time, materials and man-power.

LET US SHOW YOU THE COMPOUND DEVELOPED FOR YOUR PROBLEM!

A MAC DERMID Inc. service engineer will be pleased to show you the special MAC DERMID Inc. compound that has been especially developed for your particular product — help you determine the fastest, surest way to achieve a chemically clean basis metal prior to plating or coating — show you the newest cleaning procedures and help you install them in your plant — prove to you why so many others are today relying on MAC DERMID Inc. to speed-up and improve their cleaning room production.

MAC DERMID

INCORPORATED

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Park #200 Quench Oil

A faster oil for all Quenching Operations

Another step forward in the metal industry is this No. 200 Quench Oil recently developed in the Park Research Laboratories. It is an "accelerated" quench oil that greatly enhances the hardening of steel and is not affected by carry-over from salt baths.

This Park No. 200 Quench Oil is being used by some of the largest manufacturers in the country, and has been proved most successful in their heat treating departments.

Comparison of the hardenability curves obtained in Park No. 200 Oil with those obtained in ordinary quenching oils shows a greater surface and center hardness.

It is true that there is but a few seconds difference in cooling rates between this No. 200 Quench Oil and others but these few seconds make all the difference between partial and complete hardening or the difference between costly rejects or inspection proof work.

For complete technical data about this Park No. 200 Quench Oil or Park's No. 100 and "S" Quench Oils, phone one of our representatives listed below or write us today. No obligation, of course.

SPECIALISTS IN HEAT TREATING SINCE 1911

Park

PARK CHEMICAL CO.

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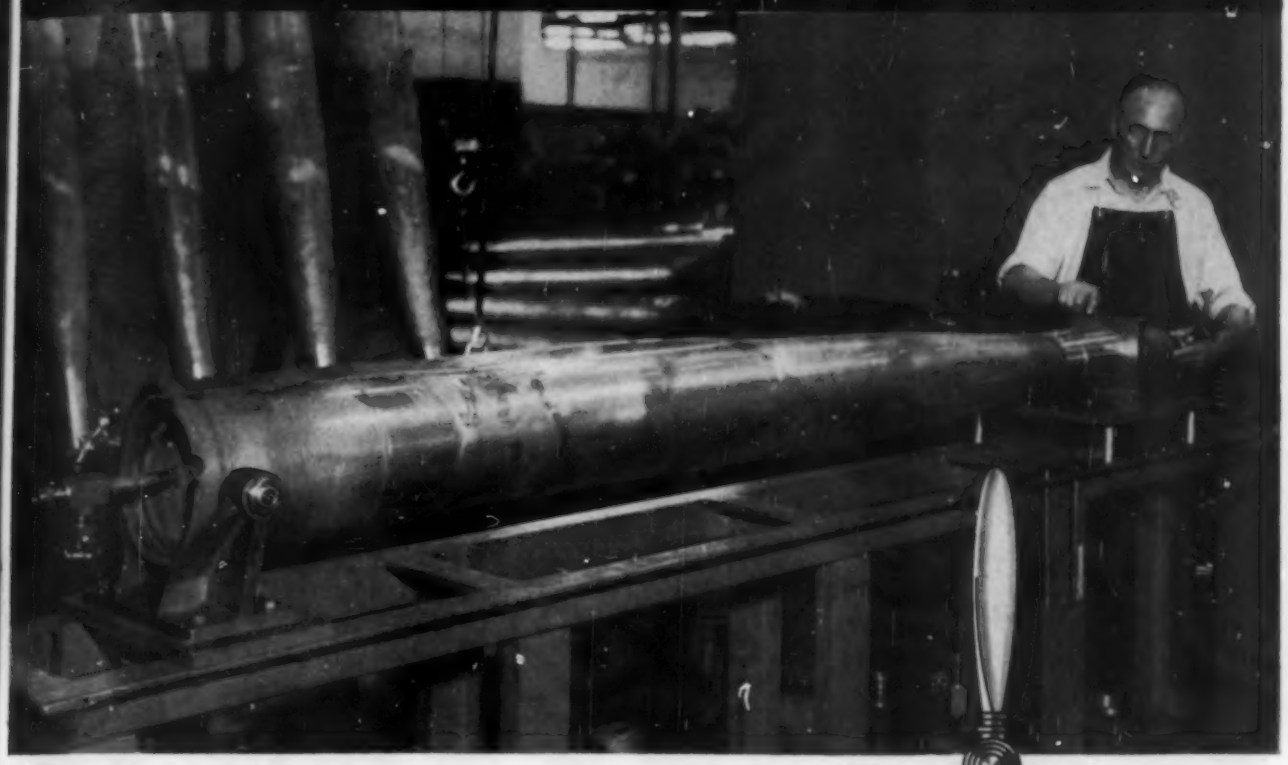
8076 MILITARY AVE. DETROIT, MICH.

Getting there FASTER with HEAVIER Loads



in planes equipped with one-piece propeller blades made from TIMKEN seamless steel tubing . . . .

War loads . . . of men and materiel . . . are heavier in the faster, bigger planes made possible by one-piece propeller blades made from Timken Seamless Steel Tubing.

When larger cargo and transport planes — requiring powerful, higher horsepower engines — were first planned, aircraft engineers sought a way of increasing propeller size without increasing propeller weight. The way was quickly found: use of hollow steel rather than solid aluminum blades.

One rapid means of producing these highly essential hollow steel propeller blades is an advanced method employed by The American Propeller Corporation, Toledo, Ohio, in manufacturing them from single pieces of Timken Seamless Steel Tubing.

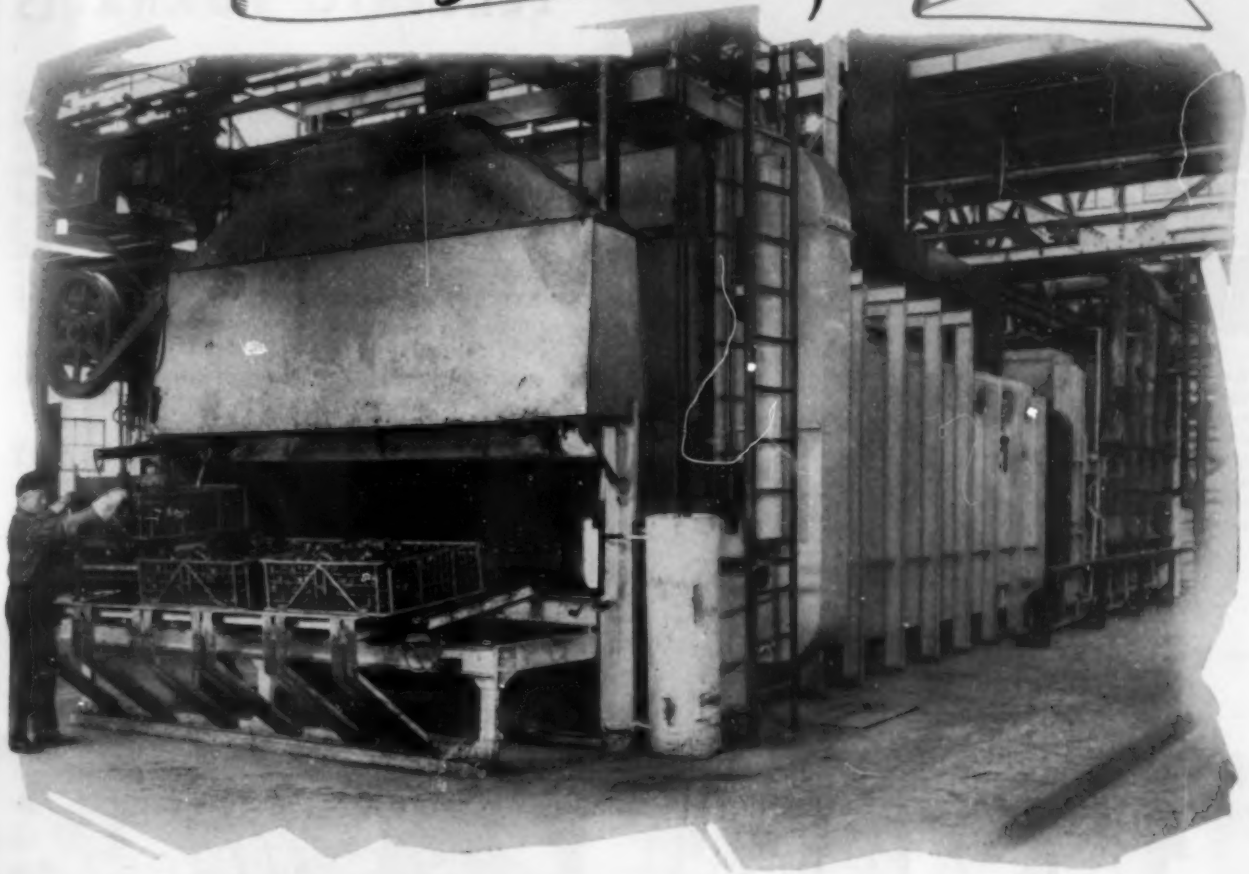
In the step shown above, locating blocks are being positioned with the same accuracy and close attention to detail that enable "American" to meet so completely the unusually high propeller requirements of the aviation industry.

* * *

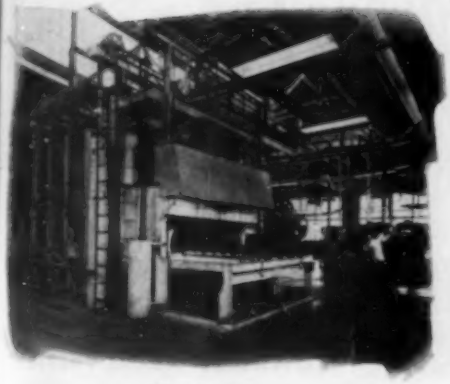
After we have broken the heart of Hitler's Germany — or even now — it may pay you to consider the many advantages of high quality Timken Seamless Steel Tubing in relation to *your* product. Timken engineers will be glad to supply you with more information or to help in actual planning — for now or for the peace. Steel & Tube Division, The Timken Roller Bearing Company, Canton, Ohio.

another **TIMKEN** *milestone*

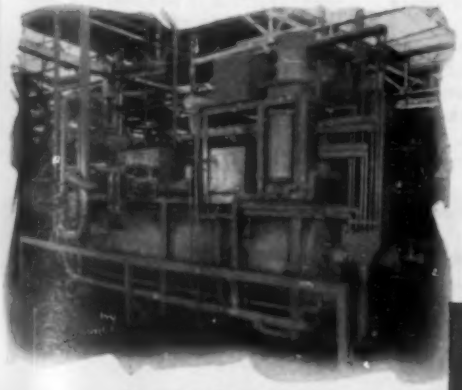
STEEL SHELL CASE *Annealing*



View from Discharge End



Charging End



Atmosphere Generator

THIS Wilson radiant tube heated, gas atmosphere control, continuous furnace is annealing over 5000 pounds per hour of steel shell cases and they are *scalefree* when they leave the furnace. In this operation, no pickling or washing is required between draws.

Write for details . . .

ENGINEERED AND CONSTRUCTED BY THE

Lee Wilson ENGINEERING Co., Inc.

20005 West Lake Road CLEVELAND, OHIO

Telephone ACademy 4670

The Wilson Annealing Unit is covered by Patents Nos. 1,862,402, 2,268,477, 2,276,326, 2,281,832, 2,288,842, and other patents pending.

INDUSTRIAL FURNACES • RADIANT TUBE HEATING • HEAT TREATING PROCESSES

INDUSTRIAL FURNACES AND SPECIAL MACHINES

for manufacturing
PLANES; TANKS; GUNS; AMMUNITION

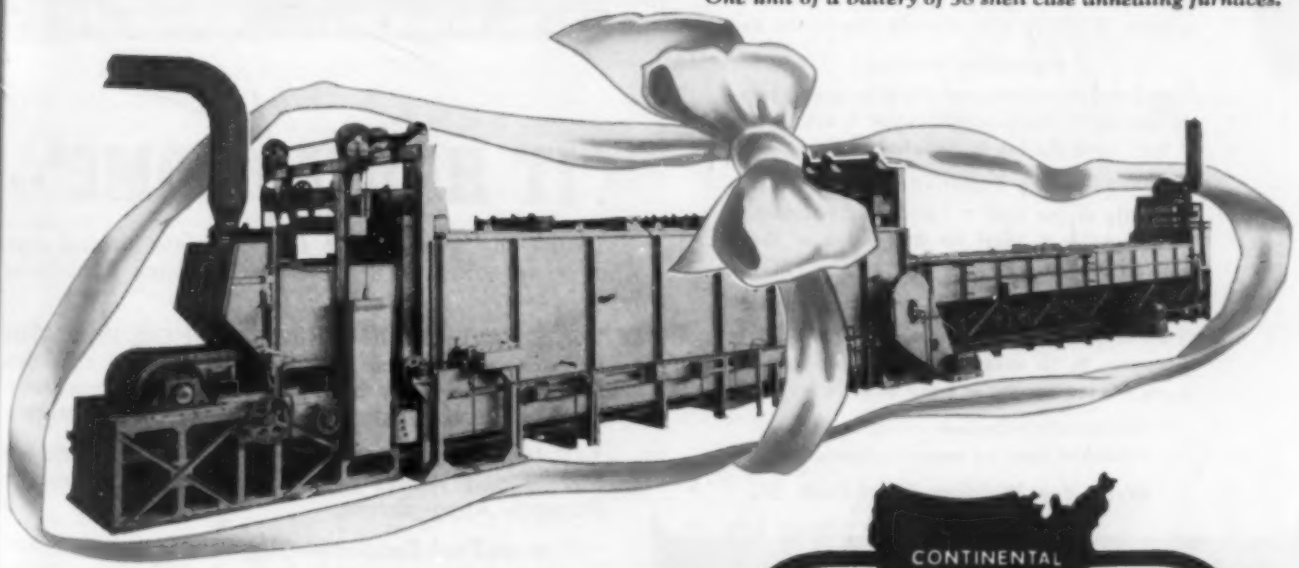
Custom Built by Continental

During the historic year just passed, Continental has designed and custom built great quantities of industrial furnaces and special machinery for the production of vital war material. This equipment, designed exclusively for war requirements, has made possible greater production in a shorter time with less man power.

This success was attained by the hearty cooperation of our Customers, our Suppliers, and our Government.

Good friends . . . to you we extend bright hopes and most cordial greetings for *Christmas & the New Year!*

One unit of a battery of 58 shell case annealing furnaces.



BEN FRANKLIN SAID:
"REMEMBER THAT TIME IS MONEY"

Let Continental save you both time and money in the design and installation of your heat treating furnaces or complete industrial plant. Continental engineers have a quarter of a century of experience back of them. This experience will save you time and money.

Custom Built by Continental

CONTINENTAL

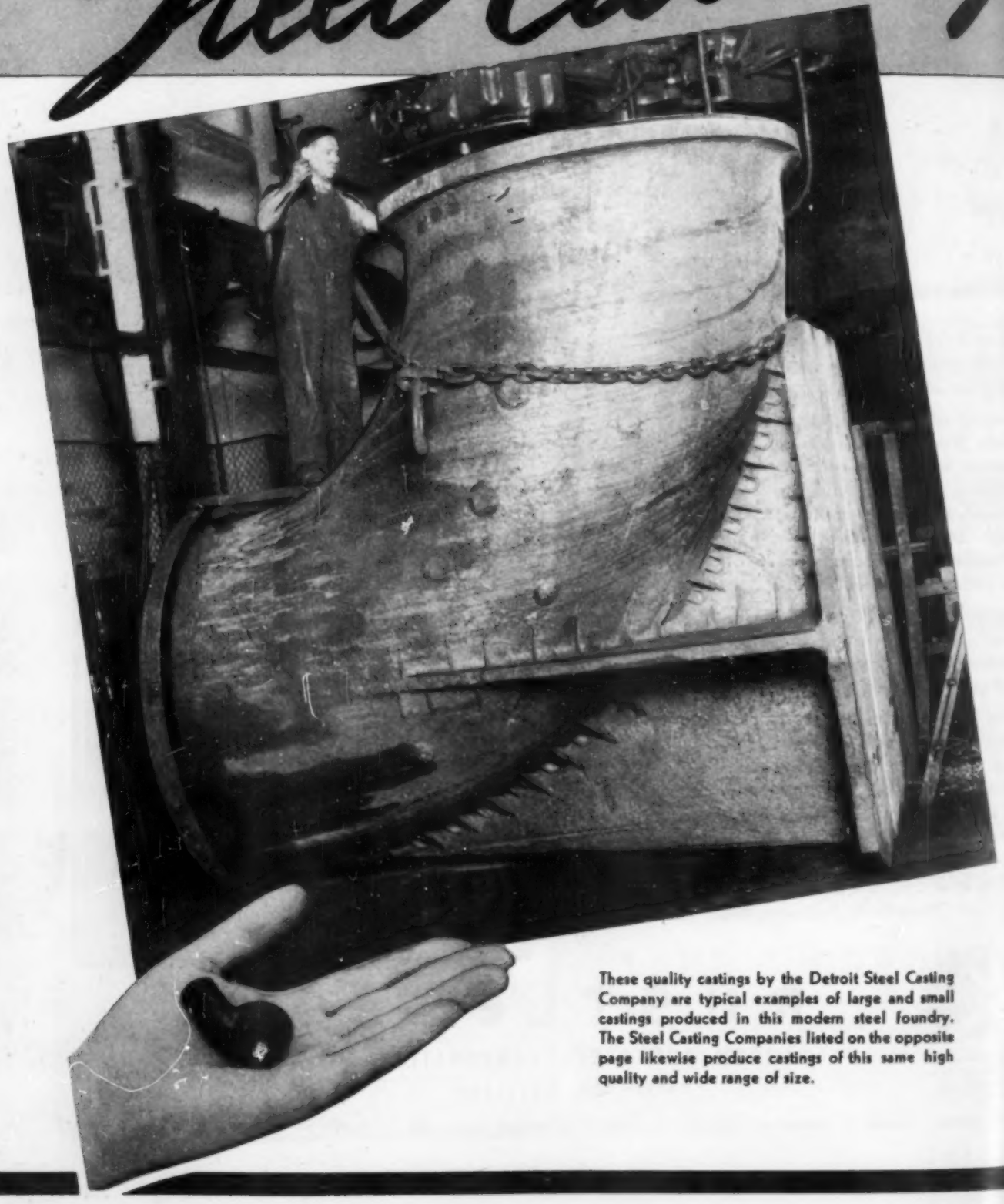
CONTINENTAL INDUSTRIAL ENGINEERS INC.

176 W. ADAMS STREET
CHICAGO, ILLINOIS

SMALL PARTS or LARGE

use

Steel Castings



These quality castings by the Detroit Steel Casting Company are typical examples of large and small castings produced in this modern steel foundry. The Steel Casting Companies listed on the opposite page likewise produce castings of this same high quality and wide range of size.

..to cut assembly and finishing costs

..to improve quality and performance

Size and weight are no longer factors in obtaining the advantages of cast steel. Small parts or large are normally available. They may be intricate in shape and of thin wall section. They will be strong, clean, uniform and accurate in all dimensions. Thus they not only offer improvement in product, but they also effect substantial savings in machining, finishing and assembly costs.

Investigate the possibilities of steel castings for the machines you are building. Get in touch with one of these experienced steel foundries listed at the right. Whether your requirements are for small parts or large units you will find competent, intelligent service. These foundries are recognized for their ability to solve difficult steel casting problems. The nearest one will be glad to cooperate with you in providing the right type of castings to meet your production needs.

Steel castings are definitely improving product quality in every one of these lines . . .

- Aeronautical
- Agricultural Machinery
- Automotive
- Bearing
- Boiler, Tank & Piping
- Bridge
- Chemical & Paint Works
- Compressors (Pneumatic)
- Conveyor & Material Handling
- Crushing Machinery & Cement Mill
- Dredge
- Electrical Machinery & Equipment
- Elevator
- Engine
- Food Processing & Packing Plant
- Foundry Machinery & Equipment
- Gas Producer & Coke Oven
- Gears
- Heat Treating Furnace & Equipment
- Hoist & Derrick
- Iron & Steel Industries
- Metallurgical Machinery
- Mining Machinery & Equipment
- Oil or Gas Field & Refinery
- Ordnance
- Overhead Crane & Charging Machine
- Paper Mill
- Printing Press
- Pump
- Railroad
- Refractory, Brickyard & Ceramic
- Refrigeration Machinery
- Road & Building Construction
- Rubber Mill
- Ship & Marine
- Shoe Machinery
- Smelting Plant
- Spray Painting Equipment
- Steam Turbine
- Street, Elevated, & Subway Cars
- Textile Machinery
- Valves, Fittings & Piping
- Well Drilling Equipment

Buffalo, N. Y.
Strong Steel Foundry Co.
51 Norris St. Riverside 2700

Tulsa, Oklahoma
Oklahoma Steel Castings Company
1200 N. Peoria. 5-9286

Houston, Texas
Texas Electric Steel Casting Company
Bringhurst & Gillespie. Fairfax 8117

Los Angeles, California
Utility Electric Steel Foundry
3334 East Slauson Avenue Kimball 4185

Cleveland, Ohio
Crucible Steel Casting Company
Almira & West 84th. WOodbine 4613

Philadelphia, Pa.
Dodge Steel Company
Tacony. MAYfair 1650

Indianapolis, Indiana
Electric Steel Castings Company
Speedway. Belmont 0400

Newark, New Jersey
American Steel Castings Co.
Avenue "L" and Herbert Street Market 3-5464

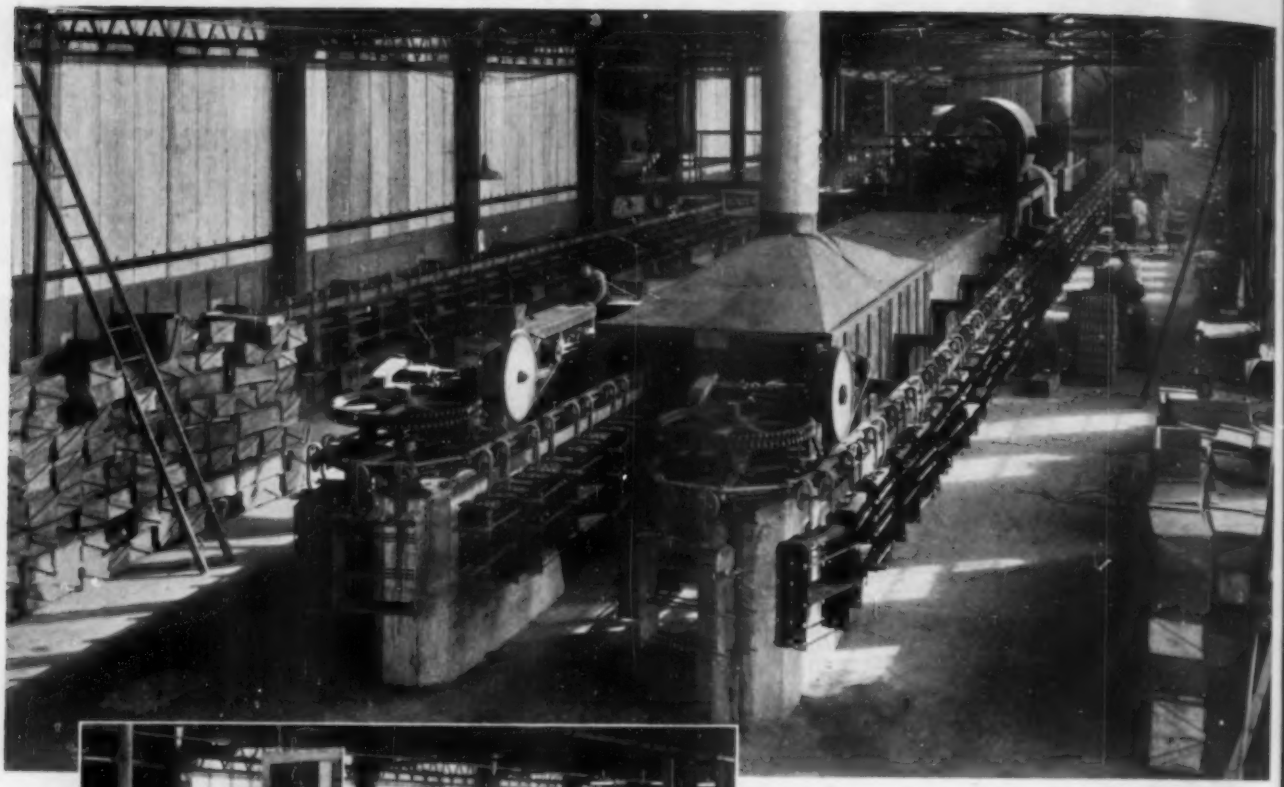
Milwaukee, Wisconsin
Sivyer Steel Casting Company
1675 S. 43rd St. Mitchell 1442

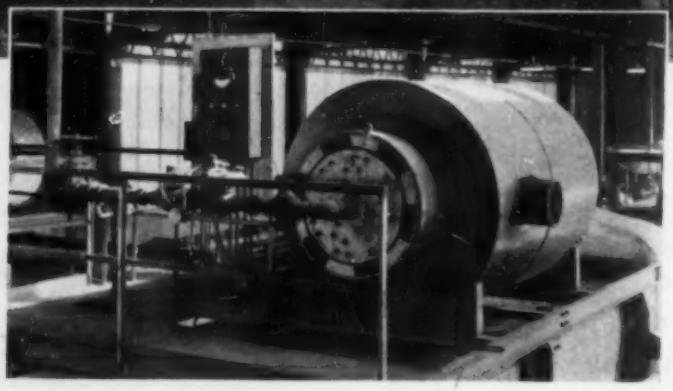
Chicago
Burnside Steel Foundry Company
1300 East 92nd Street SAGinaw 9600

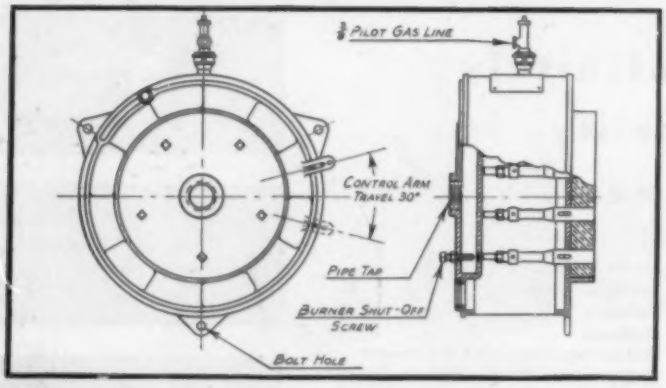
Detroit, Michigan
Detroit Steel Casting Company
4069-4140 Michigan Avenue LAfayette 5710

Toledo, Ohio
Unitcast Corporation, Steel Casting Division
Front and Millard Avenue POntiac 1545

THIS OVEN EQUIPPED WITH
NATIONAL GAS BURNER







Above sketch shows the construction of the National Air Heater Gas Burner.

Direct gas-fired Air Heater delivers uniform heat at low cost

Heating by forced convection of gases at high temperatures results in the highest efficiencies obtainable with any method of heat application. It offers rapid, uniform heating, accurate control of oven temperature and ventilation for process and safety requirements. Removal of the burners from a location in the oven to a separate combustion chamber in the gas-fired heater provides safety of operation unattainable with direct burner application.

National Gas Burners for Air Heaters have a long record of successful, dependable operation. They feature the patented Lo-Blast gas inspirator mixers and flame ports. Their design incorporates every construction which assures the safe, automatic input of gas. Write for full information.

SEND FOR THE NATIONAL MANUAL

You'll find the latest developments in gas-burning equipment in this engineering manual of the National Machine Works. It is completely outstanding because of its quick equipment selection charts, which greatly simplify the designing of any gas-burning installation. Your copy sent on request.

NATIONAL
MACHINE WORKS

Peoples Gas Building • 122 S. Michigan Ave. • Chicago 3, Ill.

No better alloy plant than this 11 acre plant exists anywhere.

●

*A new 110 ft. addition, not shown in above photos, was completed in January.

ACC

Tooled! To make the most exacting castings,—to close precision,—in quantity,—on time!

Manned! From engineering executives, foundry craftsman and Time Study Department to apprentices who have a special night course at University of Illinois foundry laboratories.

Proven! (A) As the largest manufacturer of thin section, light weight alloy castings. We anticipated the nickel-chrome shortage of our nation at war—co-operated in engineering design and tooled to make each pound of alloy do its maximum war service. (B) As the largest manufacturer of retorts, muffles, fixtures and containers for modern high speed carburizing. This is the most exacting alloy application.

Have you sent an inquiry to Alloy Casting Company? We would appreciate your doing so. Our increasing facilities may enable us to serve you promptly.

ACC

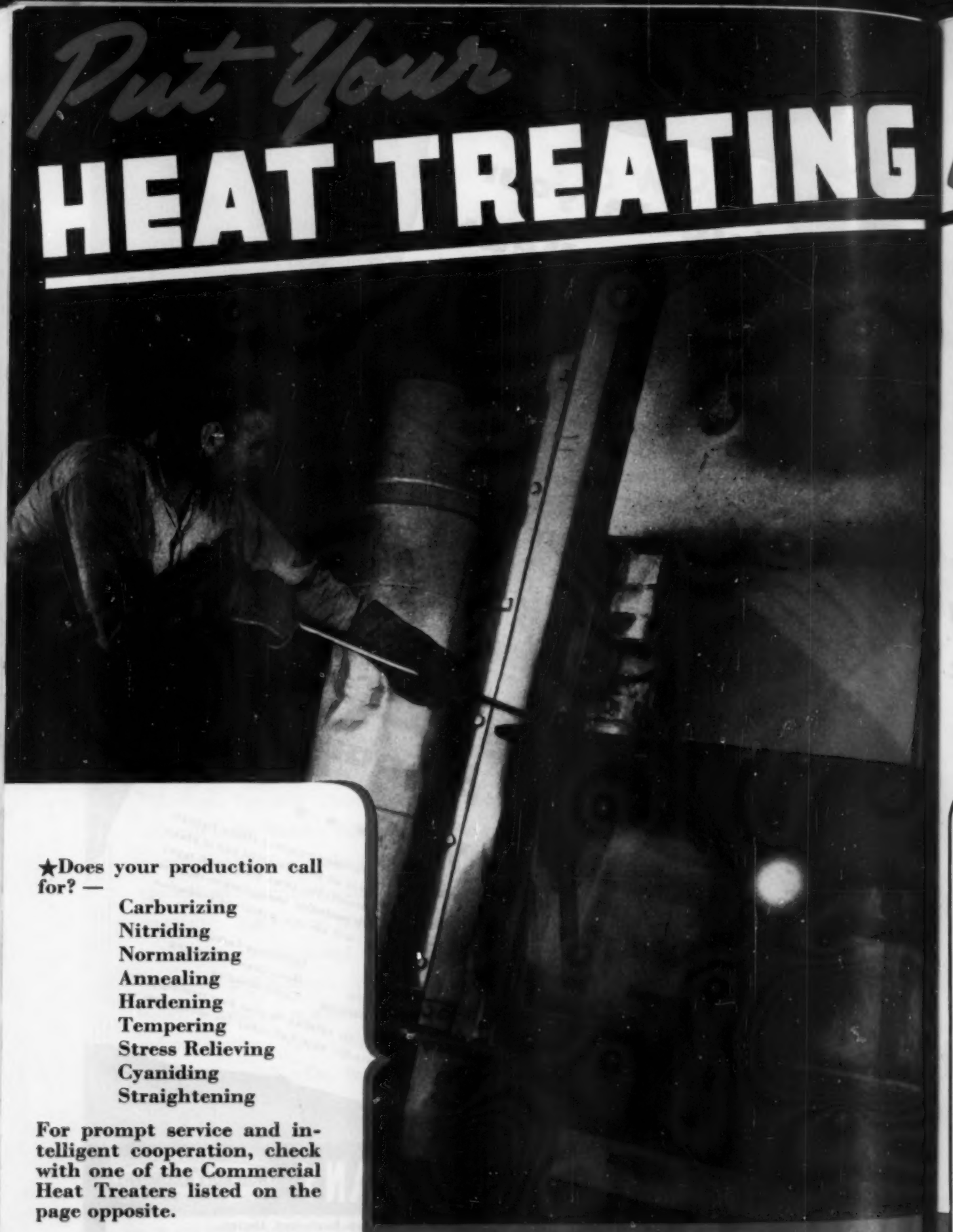
ALLOY CASTING COMPANY

CHAMPAIGN, ILLINOIS

ACC


Anticipate your peacetime Heat Treating requirements now!
BUILT BY
HOLCROFT & COMPANY
DETROIT, MICH.
. . . is prepared to assist you . . .
Although we are still operating 100% on wartime emergency orders, Holcroft engineers will be glad to consult with you in an effort to assist you in planning your peacetime production requirements. The same six general types of furnaces produced by Holcroft — with controlled atmosphere — that are performing so admirably in war work, will set new peacetime production records in:
Clean or Bright Annealing
Short Cycle Malleable Annealing
Clean Hardening, Non-Decarburizing
Light Case Carburizing
Deep Case Carburizing
Carbo-Nitriding
A Holcroft engineer has the complete solution to your heat treating problems — whether it's gas, oil, or electric heat. Call today for prompt service.
HOLCROFT & COMPANY
BUILT BY HOLCROFT & COMPANY DETROIT-MICH.
6545 Epworth Boulevard, Detroit.
In Chicago—C. H. Martin, 1358 Peoples Gas Bldg.
In Canada—Walker Metal Products, Ltd., Walkerville, Ont.

Put Your HEAT TREATING



★Does your production call for? —

Carburizing
Nitriding
Normalizing
Annealing
Hardening
Tempering
Stress Relieving
Cyaniding
Straightening

For prompt service and intelligent cooperation, check with one of the Commercial Heat Treaters listed on the page opposite.

in the hands of . . .

SPECIALISTS

In this war of metals the Commercial Heat Treater's status is truly "specialist". So varied and unpredictable are war's demands that new heat treating techniques must be devised, new methods adopted, new equipment added.

The result — a growing wealth of knowledge and experience, a store of new, modern equipment and facilities that will bring actual dollars-and-cents benefits to peacetime manufacture.

Begin now to adopt these advantages to your production. These Commercial Heat Treaters are specialists, with the modern equipment and facilities, the specialized knowledge that will be of practical value in solving many of your production problems.

Get in touch with the nearest one — today!

CALL THE COMMERCIAL HEAT TREATER NEAREST YOU — TODAY

BOSTON

New England Metallurgical Corporation
9 ALGER STREET - SOUTH BOSTON 3313

CINCINNATI

The Queen City Steel Treating Company
2978 SPRING GROVE AVE. - KIRBY 3161

CLEVELAND

The Lakeside Steel Improvement Co.
5418 LAKESIDE AVE. - HENDERSON 9100

DETROIT

Commercial Steel Treating Corporation
6100 TIREMAN AVE. - TYLER 6-6086

Commonwealth Industries
5922 COMMONWEALTH AVE. - MADISON 0573

ELIZABETH, N. J.

American Metal Treatment Company
ELIZABETH 2-2121

MILWAUKEE

Thurner Heat Treating Co.
809 W. NATIONAL AVE. - MITCHELL 6360

NEWARK, N. J.

B-M Heat Treating Co.
220-222 CLIFFORD ST. - MARKET 3-6486
N. Y. City - RECTOR 2-2732

NEW YORK

Fred Heinzelman & Sons, Inc.
154 SPRING STREET - WALKER 5-2666

Alfred Heller Heat Treating Co.
379-391 PEARL ST. - BEEKMAN 3-4534-5

PHILADELPHIA

Lorenz & Son, Inc.
1500 N. FRONT ST. - REGENT 7722 EAST 8235

Metlab Co. (Metallurgical Labs., Inc.)
1000 E. MERMAID LANE - CHESTNUT HILL 3560

Rex & Erb
LANSDALE, PA. - LANSDALE 4611

Wiedemann Machine Company
1801-31 SEDGLEY AVE. - SAGAMORE 3027
PARK 2258

PITTSBURGH, PA.

Pittsburgh Commercial Heat Treating Co.
49th ST. & A.V.R.R. - SCHENLEY 6277

PROVIDENCE

H. C. Schubert
282 RICHMOND ST. - DEXTER 1731-4245

WORCESTER, MASS.

Massachusetts Steel Treating Corp.
118 HARDING STREET - WORCESTER 37972

Here's the answer to a HEAT TREATER'S *Prayer*

Miracles do happen! Here, available for prompt delivery, is the DELAWARE Controlled Atmosphere FURNACE—a furnace unique and practical in design and simple in operation.

Wherever installed, DELAWARE Controlled Atmosphere FURNACES have proved to be the answer to every tool hardening problem on all types of steel from Straight Carbon to Moly High Speed.

Just how this unusual furnace works, a description of its low fuel and maintenance cost, and details on its seventeen outstanding features, will be found in our free booklet. Send for it now.

DELAWARE
CONTROLLED ATMOSPHERE
FURNACES

DELAWARE TOOL STEEL CORPORATION

MANUFACTURERS OF FINE TOOLS SINCE 1918

WILMINGTON **DELAWARE**

ANNOUNCEMENT

ABOUT

METAL & THERMIT METALS

Due to the many demands for Thermit in war production, we are not always able to supply all of the Metal & Thermit metals and alloys made by the Thermit alumino-thermic process.

After the war there will be, again, a plentiful supply of these pure, carbide free metals.

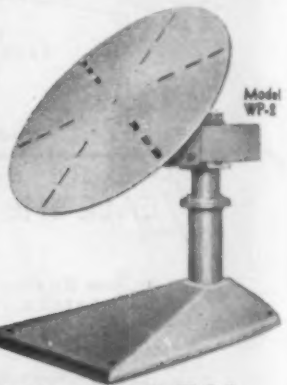
★ ★

METAL & THERMIT CORPORATION

120 BROADWAY, NEW YORK

Albany • Chicago • Pittsburgh • So. San Francisco • Toronto

P&H WELDING POSITIONERS



NEW! LOW PRICED! CUTS WELDING COSTS!

- 2500 pound capacity at surprisingly low cost.
- All-welded rolled steel construction.
- Most versatile positioner in its class. Simple and easy to operate.
- Large table area with handy slots.
- Hydraulic power tilting.
- No exposed gearing.
- Manual turning to suit welding speed. Positive table locking device.
- Telescopic elevation.
- Portable or column-in-floor mounting.
- Also available with handwheel or power turning.

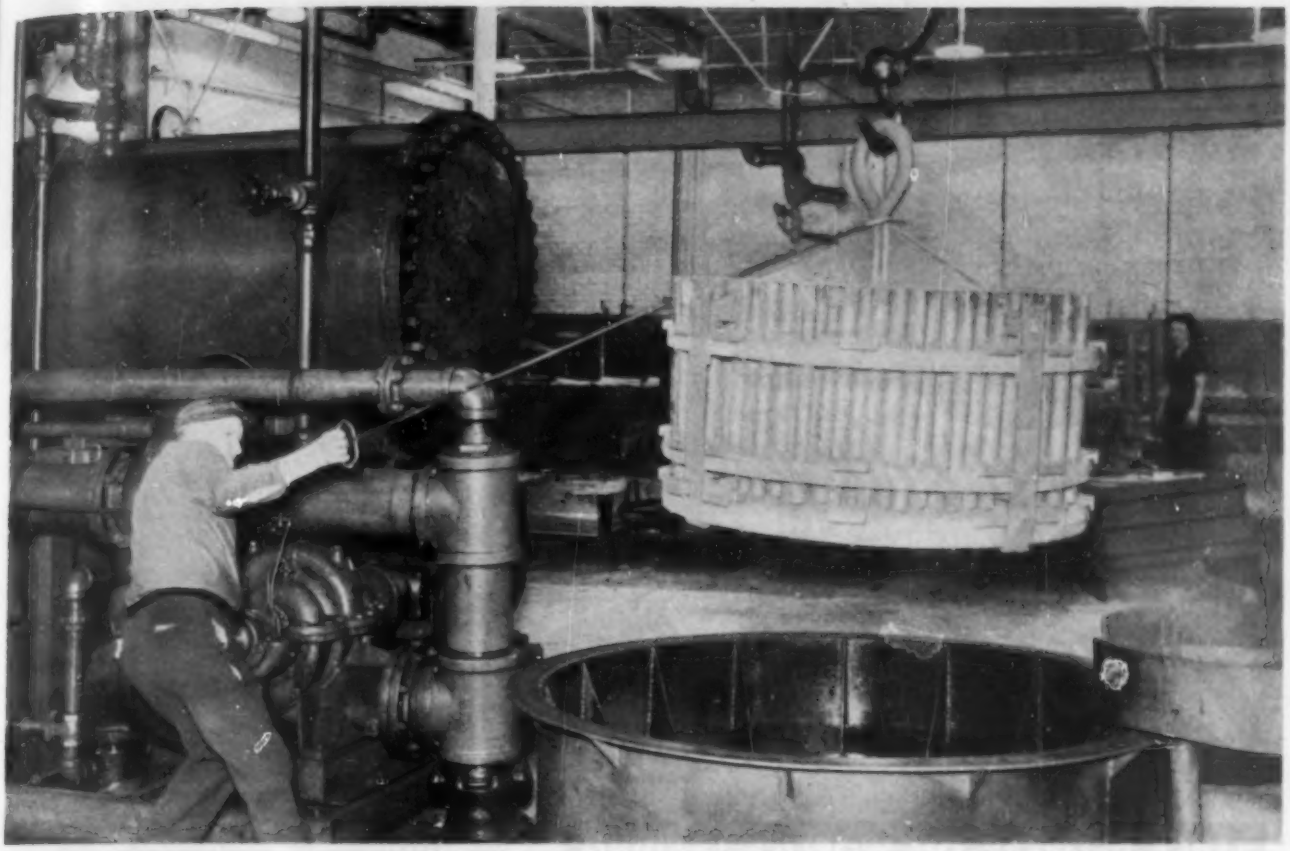
Write today for Bulletin P-2

General Offices: 4549 West National Avenue, Milwaukee 14, Wis.

HARNISCHFEGER CORPORATION

ARC WELDERS • EXCAVATORS • ELECTRIC CRANES P&H MOTORS • HOISTS • WELDING ELECTRODES

Canadian Distribution: The Canadian Fairbanks-Morse Co., Ltd.



UNIFORM QUALITY IN EVERY BATCH

. . . BECAUSE QUENCHED UNDER CONTROLLED, IDENTICAL CONDITIONS

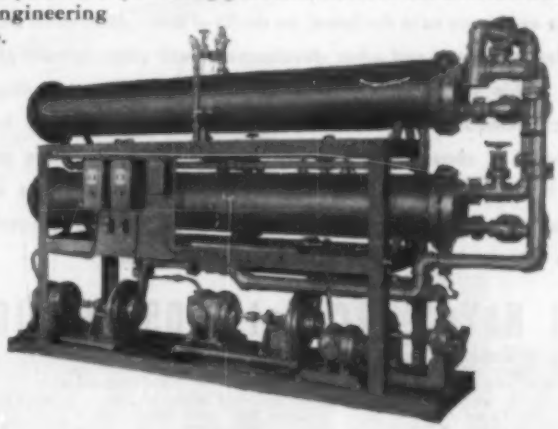
Correct oil quenching of heat-treated metals is a fine art which pays dividends in the *uniform quality* of the finished product. Quenching in an oil bath controlled by a B & G Rapid Oil Cooling System eliminates human error . . . reduces the process to a purely automatic operation, in which the final result can be calculated with mathematical certainty.

A B & G Rapid Oil Cooler circulates oil at high velocity and with extreme agitation through the quench tank. It pumps heated oil from the tank, cools it and pumps it back again, so that oil temperature is held at the desired degree all through the quench period. Thus every batch of metal is quenched under *identical conditions* and every batch emerges from the quench *identical in quality!*

For the answer to your own quenching problem, write to the Bell & Gossett Co. A complete engineering service is available.

B & G WHIRL-FLOW QUENCH TANK
Oil enters the tank at high velocity, causing violent agitation and turbulence. Sediment basket permits easy removal of scale.

B & G SELF-CONTAINED OIL COOLER
These units are completely assembled Oil Coolers, ready for connection to oil and water lines. Available in any capacity and engineered to your specific requirements.



WRITE FOR LATEST B & G RAPID OIL COOLER CATALOG

B&G

HEAT-TREATING EQUIPMENT SINCE 1916

RAPID OIL COOLERS

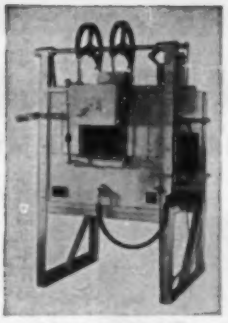
BELL & GOSSETT CO., MORTON GROVE, ILLINOIS

CHECK YOUR NEEDS

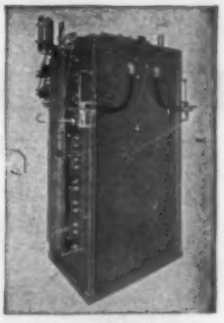
—WE'LL GIVE YOU *Action!*

EARLY DELIVERY ON WORLD'S LEADING CONTROLLED-ATMOSPHERE FURNACE FOR WIDE VARIETY OF APPLICATIONS

With our capacity increased to 9 times normal by war demands, we have finally reached the point where what seemed an insurmountable back-log is being handled on schedule. And due to scheduling well ahead by many of our customers, there are a limited number of opportunities to insert new orders, with possibility of shipment on some types on better than normal schedule. We invite and advise you to consult us on possibilities regarding the type of furnace you will need. Precision control of furnace atmosphere is today more important than ever before — and will be even more so in the future, no doubt of that. New steels and alloys, powder metallurgy and other developments will come forward in a great surge within the next few years, offering tremendous advantages over current methods, and offering the GREATEST advantage to firms best equipped to cope surely and swiftly with new heat-treating problems. Plan for "Certain Curtain" equipment at every point where precision control of furnace atmosphere is needed. Start now by discussing your needs with our nearest representative or home office.

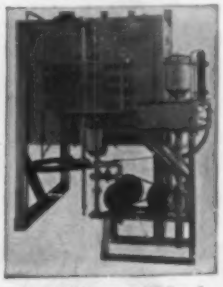


Standard furnace for hardening high speed steel tools.



Special vertical furnace for hardening large broaches up to 7 feet.

Special furnace for hardening large dies.



Special furnace for hardening MOLY STEELS without decarburization.

C. I. HAYES, INC. Est. 1905, PROVIDENCE, R. I.

R. B. HESS, 92 Liberty St., NEW YORK
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Request Bulletins

World's Leading Controlled-Atmosphere Furnace

ANNOUNCING

a change in organization

Our friends in the metallurgical field will be interested in the announcement of a change in the activities of the Adolph I. Buehler organization.

This change is made in order to enable us to maintain a close personal contact with our customers and at the same time provide expanded facilities for handling the rapidly increasing demand for metallurgical testing equipment.

A new organization, Buehler, Ltd., a partnership under my personal direction, will hereafter handle all metallurgical apparatus and sample preparation equipment.

The optical equipment will continue to be handled by the Adolph I. Buehler organization supervised by Mr. George Graves who has long been associated with my staff and who will devote all his efforts to serve you in this field.

The policy of both companies will continue, as in the past, to present equipment of the highest standard of quality in both optical and metallurgical apparatus. Some new and important developments that are anticipated in the field of metallurgical testing apparatus make this change in organization of particular significance to the metallurgist.

Adolph I. Buehler

This compact, electronic control panel (CR7503A138) can be installed on, or mounted under, the assembly bench. A calibrated dial on the front provides easy adjustment of the weld time. Time range: ½ cycle and from 1 to 10 cycles; maximum current demand: 53 amperes, at 230 or 460 volts.

New Precision Control for Small, Difficult Spot Welds

HERE'S a new electronic control unit for low-capacity resistance welders. It is especially suitable for welding small copper, brass, bronze, and steel parts which are usually soldered, brazed, or riveted.

Designed for high-speed production, this new control unit may effect as much as a 2-to-1 saving in time compared with conventional methods. The welds are uniformly good; spoilage is reduced. These results are possible because the control can be operated at speeds as high as 350 times a minute, yet welding current will be the same for each weld, and the operator has at his fingertips precise control of the time of current flow.

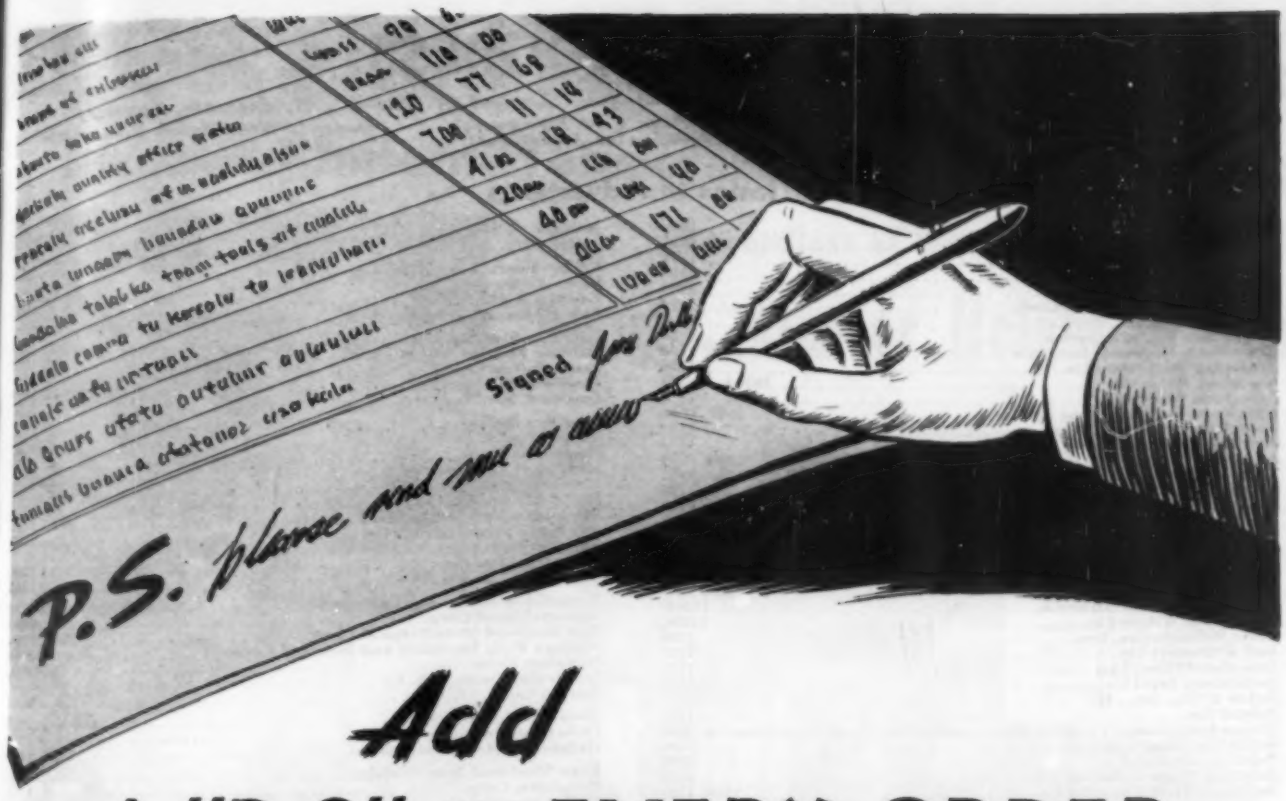
A number of these electronic control units are being used in our own factory to provide the precise control required in the manufacture of G-E electronic tubes. Since their installation, not only has production increased, but the records also show fewer rejects, more consistent welds, and lower maintenance cost.

ELECTRONIC CONTROL

General Electric has a complete line of electric equipment for resistance-welding machines, including electronic control for spot and seam-welders, weld and sequence timers, weld recorders, cable, instruments, circuit breakers, transformers, capacitors, motors, and control. Whatever your welding job, consult your welding-machine manufacturer for the right type of equipment. Or contact our nearest office; our engineers will be glad to help you. *General Electric Co., Schenectady, New York.*

Every week 192,000 G-E employees purchase more than a million dollars' worth of War Bonds.

GENERAL ELECTRIC



Add
A "P.S." to EVERY ORDER

For the last word in heating and annealing equipment, P. S., for Pressed Steel, is specified throughout American industry. It insures economy, efficiency and long wear . . . whether it be standard equipment or blueprint installation in:

Alloy Exhaust Manifolds	Bubble Caps	Radient Tubes
Alloy Retorts	Carburizing Boxes	Steel Cylinder Caps
Alloy Tubing	Cylinder Neck Rings	Thermocouple Protection Tubes
Annealing Baskets	Dipping Baskets	Tube Assemblies
Base Sheaths	Inner Covers	Tumbling Barrels
Annealing Covers	Pickling Baskets	Welded Alloy Tubing

Since 1928, The Pressed Steel Company has specialized in the construction of light-weight, strong and durable equipment designed to meet the most punishing demands of heating and annealing operations. Wartime demands for speedy and reliable production have been greatly assisted, in plants everywhere, by equipment and appliances installed or built to specification by Pressed Steel.

Write or mail YOUR specifications

The Pressed Steel Company
Wilkes-Barre, Pennsylvania

CHICAGO NEW YORK DETROIT TOLEDO HOUSTON TORONTO

METAL PROGRESS

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A. P. Ford, Western Representative
7301 Euclid Ave., Cleveland 3, Ohio
Phone: ENdicott 1919

Don Harway, Pacific Coast Representative
816 West Fifth St., Los Angeles, Calif.

Chester L. Wells, Eastern Representative
11 W. 42nd St., N. Y. City
Phone: CHickering 4-2713

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TOWER PRESS CLEVELAND

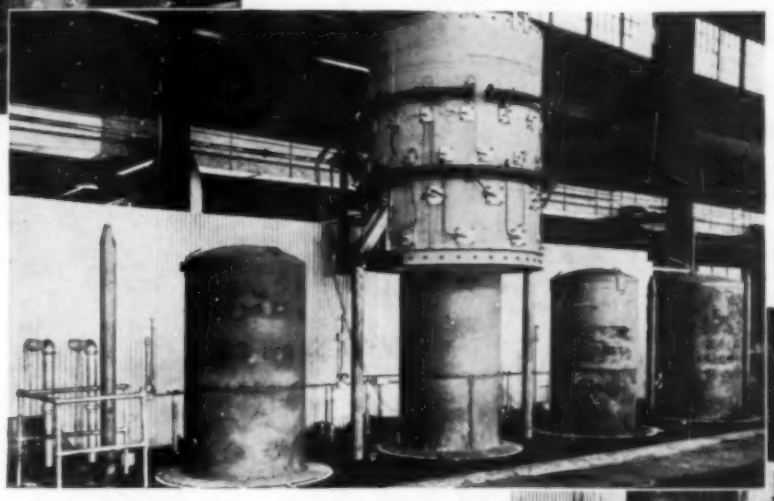
EF Gas Fired Bell Type Furnaces

Maintain Uniform Temperature Throughout Charge

Regardless of the

Weight, Size or Height of Load

(Above) An EF Bell Type Installation consisting of furnace, 4 bases, and retorts.



(Left) Each base accommodates charges up to 22,000 lbs. and coils up to 45" in diameter.

(Right) Removing a retort from base, showing bright annealed charge.

For Annealing Strip, Wire and Other Products

Equipped with special radiant type gas burners and separate automatic temperature control zones, these EF gas fired removable hood type furnaces obtain and maintain uniform temperature distribution throughout the entire charge on each and every load, regardless of weight, size or height of load.

The installation shown above was designed for annealing medium and high carbon mirror-finish cold rolled steel strip, and is equipped with special EF gas generator equipment for producing the protective atmosphere for bright annealing without decarburization. Each base accommodates charges up to 22,000 lbs. and handles coils in any width up to 45" in diameter.

This installation is equipped with a pre-mix plant for mixing the gas and air in proper proportions. This eliminates all manual burner adjustments, as the gas-air mixture is previously obtained in the machine. The high turn down ratio on burners permits use of modulating type control.

This equipment is provided with 4 bases, each with motor driven centrifugal type fan for circulating atmosphere down through the center of the charge and up between the outside of coil and the gas-tight retorts.

An extremely high rate of circulation is obtained and uniform temperature is provided and maintained regardless of the size of charge. Additional information on the above or on any other type furnace will be gladly furnished on request.

Recent outstanding production furnace installations include furnaces for bright annealing both ferrous and non-ferrous strip, wire, tubing and other ploducts . . . furnaces for the production heat treatment of tank armor castings, cartridge cases, shell forgings, bomb and gun parts, machine gun cartridge clips, aircraft and aircraft engine parts, aluminum and magnesium castings, bolts, springs, and many other allied products.

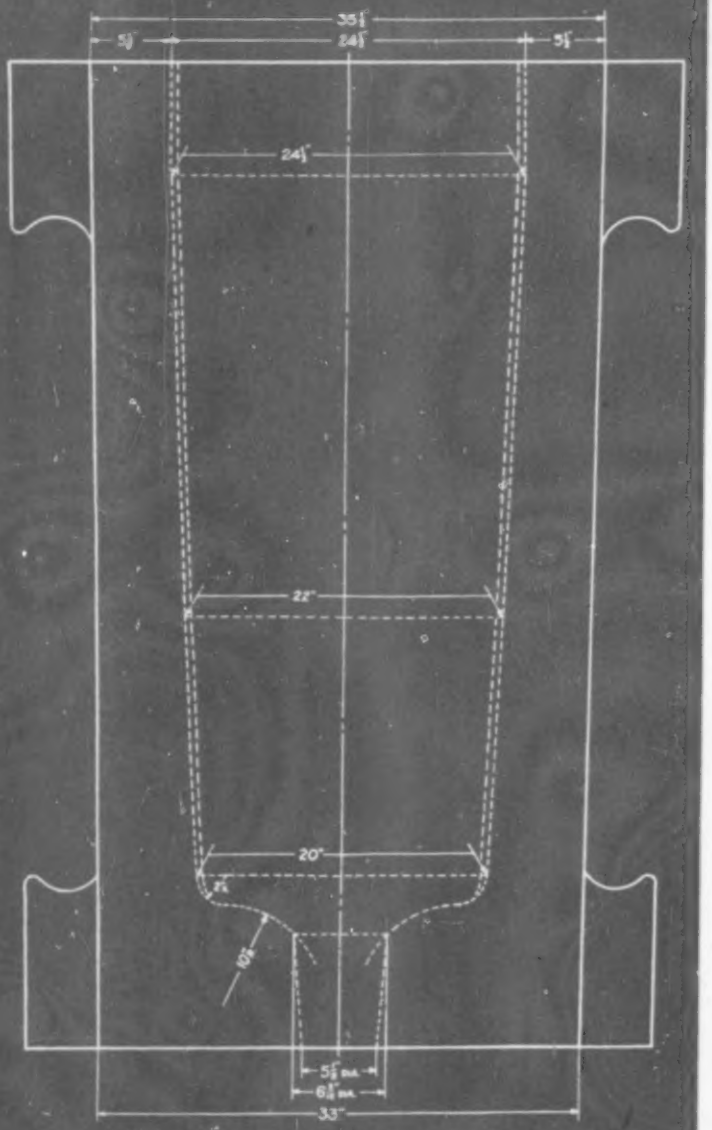
We specialize in designing and building *production* furnaces.

The Electric Furnace Co., Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces---For Any Process, Product or Production

CONSERVE IRON

with molds that save up to 20% in weight



U. S. Patents
1,643,241 - 2,190,116
2,116,587 - 2,242,703
Others Pending

Here is the vertical section of a Gathmann thin-wall multi-taper ingot mold of the type that is saving its users between 10% and 20% in mold and handling costs over previous big-end-up designs.

Until the development of this multi-taper contour, heavy mold walls were necessary to assure progressive solidification of the ingot from bottom to top, a requisite for the prevention of bridging in the solidifying ingot.

The multi-taper feature causes such rapid cooling in the lower and middle sections of the ingot that thick walls are neither necessary nor desirable.

A trial jag will convince you that this thin-walled mold is not only the most economical but the most efficient mold you've ever used. Interior soundness and homogeneity of the ingot are unparalleled, top and bottom crop loss are the minimum, and surface quality is excellent because the design prevents hanging of the ingot at any point in the mold.

We shall be glad to submit for your consideration blueprints showing one of these modern thin-wall molds in whatever size you specify.

GATHMANN *Multi-Taper*

If you have not already read the new edition of Mr. Gathmann's book, *The Ingot Phase of Steel Production*, write us for a copy. It will give you in detail the essentials for soundness and homogeneity in steel of any specification. And most important today, it will help you to get the greatest possible percentage of your furnace capacity into dependable weapons of war. Please write on your company letterhead. The Gathmann Engineering Company, Catonsville, Baltimore 28, Maryland.